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Point-of-Entry Drinking Water Treatment Systems for Superfund Applications

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POINT-OF-ENTRY DRINKING WATER TREATMENT SYSTEMS FOR SUPERFUND APPLICATIONS

by

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16. ABSTRACT

The U.S. Environmental Protection Agency (EPA) and State Superfund agencies need a technical assistance manual to assist their personnel in the selection of an effective drinking water treatment system for individual households in areas where the drinking water has been adversely affected by Superfund site contaminants and no other alternative water supply is available or feasible. Commercially available water treatment systems for individual households are of two basic types: point-of-use (POU) and point-of-entry (POE). A POU device consists of equipment applied to selected water taps to reduce contaminants at each tap. A POE device consists of equipment to reduce the contaminants in the water distributed throughout the entire structure of a house.

This study was initiated to collect monitoring, operation and maintenance, performance, and design data on existing Superfund POE water treatment systems. Evaluation of the collected data showed that the existing data are not sufficient for the preparation of a technical assistance document to meet the objectives of EPA and State Superfund personnel.

There is a need for additional study to develop a technical assistance document. Because most of the existing data and field experience related to POE water treatment is concerned with granular activated carbon filters and air strippers for the treatment of organic contaminants, further detailed study should center around these two technologies.

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FOREWORD

Today's rapidly developing and changing technologies and industrial products and practices frequently carry with them the increased generation of materials that, if improperly dealt with, can threaten both public health and the environment. The U.S. Environmental Protection Agency is charged by Congress with protecting the Nation's land, air, and water resources. Under a mandate of national environmental laws, the agency strives to formulate and implement actions leading to a compatible balance between human activities and the ability of natural systems to support and nurture life. These laws direct the EPA to perform research to define our environmental problems, measure the impacts, and search for solutions.

The Risk Reduction Engineering Laboratory is responsible for planning, implementing, and managing research, development, and demonstration programs to provide an authoritative, defensible engineering basis in support of the policies, programs, and regulations of the EPA with respect to drinking water, wastewater, pesticides, toxic substances, solid and hazardous wastes, and Superfund-related activities. This publication is one of the products of that research and provides a vital communication link between the researcher and the user community.

The report presents the findings of the study to evaluate existing data and field experiences on the use of drinking water treatment systems for individual households. Such systems are being used in areas where the homeowner's well water has been contaminated with toxic compounds from a Superfund site and where no other alternative water supply is available or feasible.

For further information, please contact the Superfund Technology Demonstration Division at the Risk Reduction Engineering Laboratory.

E. Timothy Oppelt, Director
Risk Reduction Engineering Laboratory

ABSTRACT

The U.S. Environmental Protection Agency (EPA) and State Superfund agencies need a technical assistance manual to assist their personnel in the selection of an effective drinking water treatment system for individual households in areas where the drinking water has been adversely affected by Superfund site contaminants and no other alternative water supply is available or feasible. Commercially available water treatment systems for individual households are of two basic types: point-of-use (POU) and point-of-entry (POE). A POU device consists of equipment applied to selected water taps to reduce contaminants at each tap. A POE device consists of equipment to reduce the contaminants in the water distributed throughout the entire structure of a house.

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CONTENTS

	Page
Foreward	iii
Abstract	iv
Figures	v
Tables	v
Unit Conversion Table	vii
Acknowledgements	viii
Sections	
1. Introduction	1
Background and objectives	1
Phase I data collection and evaluation	2
Report organization	3
2. POE System Contaminants of Concern	4
Superfund site contaminants	4
Contaminants at sites where POE technology is applied	4
3. POE Treatment Systems	9
Granular-activated-carbon filter systems	9
Air stripper systems	16
System performance and effectiveness	20
Residuals handling and disposal	21
POE system costs	25
4. Summary and Recommendations	29
Phase I findings	29
Data quality and completeness	30
Recommendations	30
References	32
Appendices	
A. Regional, state, and local contacts and list of manufacturers and suppliers	33
B. Substances found at proposed and final National Priorities List (NPL) sites	37
C. An OSC's guide to point-of-use activated-carbon systems preliminary design	46

FIGURES

Number		Page
1a	Schematic of a Single GAC Unit Treatment System	10
1b	Schematic of a Dual GAC Unit Treatment System	10
2	Comparison of Henry's Law Constants for Selected Organics	17
3	Schematic of a Packed-Tower Aeration System	18
4	Schematic of Lowry's Diffused Aeration System	19

TABLES

Number		Page
1	Summary of Contaminants and Concentration Ranges at Individual Households Before Water Treatment	6
2	Influent Contaminant Concentrations at Superfund Sites	8
3	Summary of Existing Data from Phase I of POE Water Treatment Study	22
4	Cost Data for POE GAC Units at the Byron Johnson Salvage Yard Site, Byron, Illinois	27
5	Present Worth Evaluation for GAC Filter Installation	28

UNIT CONVERSION TABLE

	English (U.S.)	Metric (SI)
Area:	1 ft^2	9.2903×10^{-3} m^2
	1 in^2	6.4516 cm^2
Flow Rate:	1 gal/min	6.3090×10^{-5} m^3/s
	1 gal/min	6.3090×10^{-2} L/s
	1 Mgal/d	43.8126 L/s
	1 Mgal/d	3.7854×10^{3} m^3/d
	1 Mgal/d	4.3813×10^{-2} m^3/s
Length:	1 ft	0.3048 m
	1 in	2.54 cm
	1 yd	0.9144 m
Mass:	1 lb	4.5359×10^{2} g
	1 lb	0.4536 kg
Volume:	1 ft^3	28.3168 L
	1 ft^3	2.8317×10^{-2} m^3
	1 gal	3.7854 L
	1 gal	3.7854×10^{-3} m^3

ft = foot, ft^2 = square foot, ft^3 = cubic foot
in = inch, in^2 = square inch
yd = yard
lb = pound
gal = gallon
gal/min = gallons per minute
Mgal/d = million gallons per day
m = meter, m^2 = square meter, m^3 = cubic meter
cm = centimeter, cm^2 = square centimeter
L = liter
g = gram
kg = kilogram
m^3/s = cubic meters per second
L/s = liters/sec
m^3/d = cubic meters per day

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SECTION 1

INTRODUCTION

1.1 BACKGROUND AND OBJECTIVES

Commercially available water treatment systems for individual households are of two basic types: point-of-use (POU) and point-of-entry (POE). A POU device consists of equipment applied to selected water taps to reduce the contaminants at each tap. A POE device consists of equipment applied to water entering a house or building to reduce the contaminants in the water distributed throughout that structure. The POE devices can be applied in such a manner that water to be used outside the structure (i.e., for watering the lawn, etc.) is not treated.

Superfund-financed POU and POE water treatment systems have been installed in individual households where the homeowner's well water has been contaminated with toxic compounds from a Superfund site. These installations have been made on a case-by-case basis depending on the resourcefulness of the persons involved.

The U.S. Environmental Protection Agency (EPA) and state Superfund agencies need a technical assistance manual to assist their personnel in the selection of an effective drinking water treatment system for individual households and to educate household residents in the proper operation and maintenance of such systems to assure short-term or long-term (as required) effectiveness. This study was initiated to collect monitoring, operation and maintenance, performance, and design data on existing Superfund POE water treatment systems. These data will then be evaluated for completeness and quality, after which it will be determined if further study is needed or if existing data are sufficient for the preparation of a technical assistance document that will meet the objectives of EPA and state Superfund personnel.

The Gulf South Research Institute of New Orleans conducted an extensive study of POU water treatment for the EPA in May 1979. Since that study, POU devices may be different or have been improved; however, POU treatment systems are not specifically addressed in this document.

Point-of-entry systems can take a variety of forms, entail the use of various technologies, and be used either singularly or in combination to address numerous water quality problems. Generally, the three contaminant categories of concern are organic compounds, inorganic compounds, and microbiological agents. The most common POE systems for removal of organic chemicals involve the use of granular activated carbon (GAC) and/or aeration. Those used for removal of inorganic contaminants can involve reverse osmosis (RO) or deionization (DI). Systems used to eliminate microbiological agents may include filtration (through ceramic filters), chemical disinfection, and ultraviolet (UV) irradiation.

When properly selected, operated, and maintained, POE systems can be both effective and safe. Often, the operation and maintenance of installed units is critical to health protection. For example, GAC filters can act as a growth medium for bacteria, but if properly operated, the microbial growth may not be a problem. In some cases (discussed in Section 3.0), water being treated with GAC may require some type of disinfection (e.g., UV irradiation).

1.2 PHASE I DATA COLLECTION AND EVALUATION

This report presents the findings of the study to evaluate POE water treatment systems for Superfund applications. It involved an assessment of the status of currently operating POE systems at Superfund sites and the collection and evaluation of available operating, performance, and design data for these systems. Based on this assessment, recommendations are made concerning the development of a technical assistance manual. Active POE systems were identified at non-Superfund sites where conditions are similar to those found at Superfund sites; that is, comparable contaminant levels and mixtures have been detected in the aquifer of concern. These sites will be referred to throughout the report as comparable sites.

Data collection consisted of contacting EPA Regional Superfund offices to identify sites where POE treatment is being used. Several state and

local agencies also were contacted to obtain information related to state-supervised POE system installations. The available information consisted of monitoring data, system descriptions, some system design details, and operation and maintenance practices. A list of the Regional, state and local contacts is provided in Appendix A.

Several suppliers/manufacturers of the POE treatment systems also were contacted to obtain information on the design and operation of their systems. A list of contacts is also presented in Appendix A. Information on GAC filter systems and aeration systems was obtained from these sources.

1.3 REPORT ORGANIZATION

Section 2 of the report contains a discussion of the types and levels of contaminants being treated by POE technologies at Superfund sites. Section 3 presents the types of POE treatment systems currently being applied and includes available information on specifications for POE systems, operation and maintenance practices, performance and treatment effectiveness, waste and residuals handling practices, and cost information. Section 4 presents the findings of the study and recommendations for developing a technical assistance document for the selection and operation of POE treatment at Superfund sites.

SECTION 2

POE SYSTEM CONTAMINANTS OF CONCERN

2.1 SUPERFUND SITE CONTAMINANTS

The EPA Office of Emergency and Remedial Response (OERR) developed a list of substances found at proposed and final National Priorities List (NPL) sites as of October 1986 (Appendix B). The list comprises 360 chemical compounds or classes of compounds and the frequency with which they occur at Superfund sites. It gives a general idea of the types of contaminants that may be of concern when POE treatment is being considered; however, no information is provided concerning contaminant levels or the environmental media in which the contaminants have been detected.

According to OERR, volatile organic compounds (VOCs), heavy metals, polychlorinated biphenyls (PCBs), phenols, and cyanide are the predominant compounds found at NPL sites. The VOCs include trichloroethylene (TCE); toluene; benzene; chloroform; 1,1,1-trichloroethane (TCA); tetrachloroethylene (PCE); xylene; ethyl benzene; 1,2-trans-dichloroethylene (1,2-DCE); methylene chloride; 1,1-dichloroethane (1,1-DCA); 1,1-dichloroethylene (1,1-DCE); and vinyl chloride. The most frequently occurring heavy metals include lead, chromium, zinc, cadmium, arsenic, copper, mercury, and nickel.

2.2 CONTAMINANTS AT SITES WHERE POE TECHNOLOGY IS APPLIED

Point-of-entry water treatment systems are currently being applied at Superfund or comparable sites where drinking water has been contaminated predominantly by organic compounds. Inorganic contaminants are present in some cases, but they are not the primary concern at these sites. The main contaminants are the chlorinated solvents, including TCE; PCE; 1,1,1-TCA; DCA; and DCE. Some water contaminated with petroleum products is also being treated with POE technology. Two different locations have pesticide

(aldicarb and ethylene dibromide) contamination problems to which POE treatment is being applied. In addition, POE treatment technology, specifically air stripping, is being used to treat radon-contaminated water. Although radon contamination is not addressed by Superfund, the problem and treatment technology are similar to those for a Superfund-related problem and thus will be discussed in this report.

Table 1 presents the contaminants of concern and their influent levels at sites identified during the study efforts. These ranges of values represent monitoring data obtained during the study. The samples were collected at the individual households before the water flowed into the treatment systems. Most of the existing POE treatment systems were identified in EPA Regions 1 through 5, as indicated in Table 1.

A summary of contaminants detected at the Superfund sites where POE treatment is being applied and their concentration ranges is presented in Table 2. Approximately 200 POE water treatment systems have been installed at the Superfund sites identified during this study.

TABLE 1. SUMMARY OF CONTAMINANTS AND CONCENTRATION RANGES AT INDIVIDUAL HOUSEHOLDS BEFORE WATER TREATMENT

EPA Region	Site name and location	Contaminant	Influent range, µg/liter
1	Petroleum products contamination sites, State of Maine	Petroleum products, including gasoline and No. 2 fuel oil	1,000-240,000
1	Radon contamination sites, State of Maine	Radon (highest value reported)	40,000 pC/L
2	Suffolk County Water Treatment District, Suffolk County, NY	Aldicarb	7-500
2	Olean Site Cattaraugus County, NY	TCE	1-3,600
2	American Thermostat Site, Green County, NY	PCE	2,000-144,500
3	Pompey Site, Onendaga County, NY	TCE trans-1,2,-DCE 1,1-DCA (current high values)	5 700 2
3	Deardorff Drive Site, York County, PA	TCE	190-4,600
3	Cryochem Groundwater Site, Berks County, PA	DCE TCE PCE DCA 1,1,1-TCA	25-1,700 1-18 2-12 4-50 20-570
3	Adamstown Site, Adamstown, MD	TCE 1,1,1-TCA 1,1-DCA 1,1-DCE	2-520 2-51,000 2-210 3-570
3	Hereford Township Groundwater Site, Berks County, PA	TCE PCE	20-22,900 1-1,000

(continued)

TABLE 1 (continued)

EPA Region	Site name and location	Contaminant	Influent range, µg/liter
3	North Road Site, Monroe County, PA	TCE	10-7,000
		1,2-DCE	10-290
		PCE	20-30
4	EDB Program Polk and Jackson Counties, FL	Ethylene dibromide (EDB)	0.5-800
4	Non-EDB Program, State of Florida (one sampling round)	Benzene	210
		Ethylene benzene	38
		Toluene	8
		Total xylenes	63
		Naphthalene	12
		1,2-DCA	89
		Total hydrocarbons	220
5	Byron Johnson Salvage Yard Site, Byron, IL	TCE	50-500
		PCE	1-6
5	Main Street Well Field Site, Elkhart, IN	TCE	<10-5,000
		Carbon tetrachloride	<10-7,500
5	Industrial Excess Landfill Site, Uniontown, OH	Vinyl chloride	4-7
		Chloroethane	1-2

TABLE 2. INFLUENT CONTAMINANT CONCENTRATIONS AT SUPERFUND SITES

Contaminant	Number of occurrences within ranges*			
	1 to 100 µg/l	100 to 1000 µg/l	1000 to 5000 µg/l	>5000 µg/l
Trichloroethylene	85	60	17	3
Tetrachloroethylene	35	8	1	1
1,1-Dichloroethane	19	ND	ND	ND
1,1,1-Trichloroethane	13	16	3	1
1,2-Dichloroethylene	8	7	1	ND
1,1-Dichloroethylene	5	ND	ND	ND
Vinyl chloride	9	ND	ND	ND
Chloroethane	9	ND	ND	ND
Carbon tetrachloride	8	10	ND	ND

* The number of occurrences represents the highest concentration of a contaminant at an individual household. A total of approximately 200 POE water treatment systems were counted at the identified Superfund sites.

ND - Not detected.

SECTION 3

POE TREATMENT SYSTEMS

The POE treatment systems identified during this study are used to treat organic contaminants or radon. They fall into two general categories: 1) granular-activated-carbon (GAC) filters, and 2) air strippers. Each technology is discussed separately.

3.1 GRANULAR-ACTIVATED-CARBON FILTER SYSTEMS

Granular-activated-carbon (GAC) filtration has proven to be a successful technology for treating water contaminated with organic compounds. The activated carbon adsorbs the organic contaminants and thereby reduces the contaminant load in the water stream. The GAC eventually becomes saturated with the contaminants and must be replaced so that it will continue to provide effective treatment.

The GAC filter systems currently being applied at Superfund sites consist of either a single carbon unit or two units connected in series. Some of the systems are also equipped with prefilters to remove particulates, water meters to measure flow, and ultraviolet (UV) light to disinfect the water after carbon treatment. The two-carbon-unit systems generally have sampling ports before the first carbon filter, between the two filters, and after the second filter. Schematic diagrams of single and dual carbon filter systems are presented in Figures 1a and 1b.

Most of the GAC treatment systems applied at Superfund sites are of the two-filter design. The second filter acts as a backup for the first; if the first filter should reach breakthrough, the second filter will provide continued treatment and protection. When filter replacement is necessary, the first filter is usually removed, the second filter is moved to the primary position in the series, and a new filter is placed in the secondary position. This procedure permits optimal use of the effective life of the activated

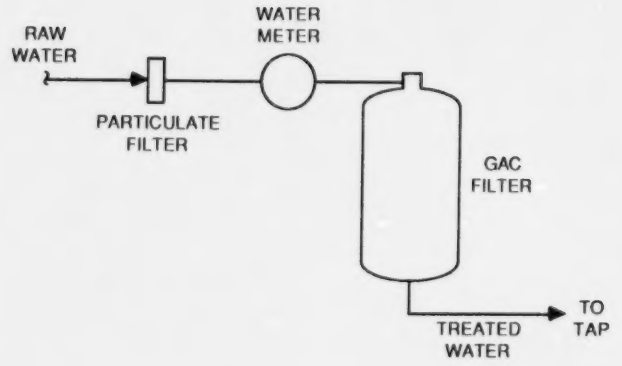

Figure 1a. Schematic of a single GAC unit treatment system.

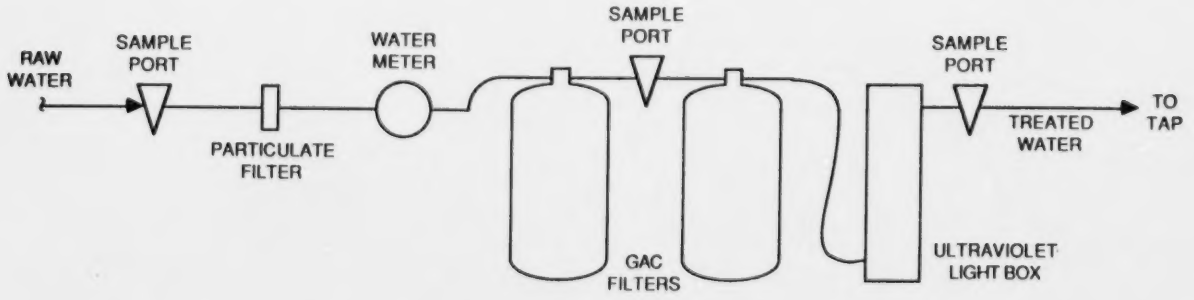

Figure 1b. Schematic of a dual GAC unit treatment system.

carbon and provides satisfactory treatment of the contaminated water. (Disposal of saturated carbon is discussed in Section 3.4.)

A single-filter system does not provide a backup filter; therefore the replacement scenario is different. In Suffolk County, New York, where the most single-carbon-filter systems were identified, the systems are equipped with an automatic backwash function to prevent the filter from being clogged by particulate and/or bacterial buildup. Quarterly monitoring of the systems is required to detect breakthrough. In Florida, where several single-filter units are in use, the effective carbon life is estimated based on waterflow and expected contaminant loading, and the filters are replaced on a regular basis before breakthrough is expected to occur. Water monitoring is conducted on a quarterly basis to verify the security of the system.

GAC Filter System Design Features

The GAC filter systems currently being applied at the various sites identified in this study are similar in design and operation. Most of the systems consist of two carbon filters in series preceded by a prefilter for particulate filtering and followed by a UV light for disinfection. The various systems identified in EPA Regions 2, 3, and 5; Suffolk County, New York; and the State of Florida are briefly described in the following subsections. Suffolk County and the State of Florida are working on these drinking water problems independent of EPA.

EPA Regions--

Region 2--At the Olean Site in Olean, New York approximately 30 dual carbon filter systems have been installed to treat water contaminated by TCE at levels as high as 3600 µg/liter. The system typically consist of two GAC columns in series preceded by a particulate filter and water meter. Sampling ports are located before the first GAC filter, between the two filters, and after the second filter. A detailed description of the system and its design is provided in "An OSC's Guide to Point of Use Activated Carbon Systems, Preliminary Design" by Robert M. Cobiella, P.E. which is presented in Appendix C.

Region 3--The POE GAC systems identified at Superfund sites in Region 3 consist of a prefilter, a flowmeter, two carbon cells in series, and a UV

light. Each carbon cell contains 1.5 to 2.0 ft^3 of granular activated carbon. Where extremely high levels of VOCs exist (e.g., 44,000 µg/liter TCE), several of the systems have a POE packed-tower air stripper connected to the beginning of the treatment train. The air stripper removes much of the VOCs from the influent water and thereby extends the effective life of the carbon filters.

Region 5--The POE GAC treatment systems used at the Superfund sites in Region 5 consist of two carbon filters in series preceded by a prefilter (to prevent clogging) and a flowmeter. No detailed information was available on these treatment units.

Suffolk County, New York--

Approximately 3000 POE GAC filters have been installed in Suffolk County, New York to treat aldicarb-contaminated ground water. The individual systems contain a single filter with 1.0 ft^3 of granular activated carbon. The unit, which is 10 inches in diameter and 36 inches high, is equipped with an automatic backwash function to prevent clogging of the filter.

State of Florida EDB Program--

The residential filtration systems being used in Florida consist of two GAC units in series. The system is installed between the existing pressure tank and the tap. A sediment filter and a water meter are installed in front of the carbon units. The sediment filter, a disposable cartridge, removes any particles larger than 5 micrometers to prevent the carbon units from clogging. The water meter permits accurate measurement of the water passing through the units. A UV light is installed after the second filter to disinfect the treated water. Sampling ports are placed before the sediment filter and after each adsorption unit.

Each adsorption tank is 10 inches in diameter and 54 inches high and is made of polyester fiberglass. Each tank contains 1.5 ft^3 of granular activated carbon. The remaining volume is occupied by a PVC distributor and gravel support media. The tanks are connected by PVC piping, and all valves are either brass or hard copper.

The adsorption system is designed for a maximum flow rate of 5 gallons per minute (gpm), which provides a real contact time of 2.2 minutes. A fully opened faucet allows a flow rate of approximately 3 gpm, which provides a real contact time of 3.7 minutes (Gentry and Dean 1984).

Operation and Maintenance Practices

The operation and maintenance (O&M) of GAC filter treatment systems can be critical to the effectiveness of the water treatment. Improper O&M practices can result in poor treatment performance and possible health risks. The O&M practices for GAC treatment units center around controlling bacterial growth, preventing filter clogging, and replacing carbon filter units.

The GAC serves as an excellent medium for bacterial growth. A silver-impregnated GAC has been developed as a bacteriostatic mechanism; however, in most cases it has not been effective in halting bacterial growth (Gentry and Dean 1984). A more successful approach has involved disinfection of the GAC-treated water. Ultraviolet light irradiation is used in many of the existing POE GAC treatment systems. Yale University is currently conducting a detailed study of the health effects of bacterial growth in relation to POE GAC treatment for the EPA's Office of Research and Development.

Because GAC filters can become clogged with particulates and bacteria, two approaches have been developed to deal with this problem. One entails installing a particulate filter before the carbon filters; the other involves periodically backwashing the carbon filters. The particulate filter or prefilter is changed on a regular basis, which can be done by the homeowner. The second approach, backwashing, involves flushing the carbon bed with countercurrent, treated water to wash away particles (e.g., iron or magnesium) or bacteria that have accumulated on the filter and blocked the pores. The backwash is generally sent to a sump inside the house and eventually directed to the sanitary sewer or septic tank.

The critical parameter in operating a POE GAC treatment unit is the effective life of the activated carbon. The effectiveness of the treatment is directly related to the adsorptive capacity of the GAC for each contaminant. When the carbon becomes saturated with contaminants, breakthrough is likely to occur, which allows the contaminants to reach the tap untreated. Various methods have been employed by EPA, State, and local agency personnel for estimating the effective life of a GAC unit including those based on carbon adsorption theory, laboratory testing, and field applications. Specific cases are discussed in Section 3.0.

Adsorption is the adherence of atoms or molecules of a gas or liquid to the surface of another substance, which is believed to be caused by unbalanced forces acting on the surface atoms of the adsorbent. A surface tension, or energy per unit surface area, is formed since these surface atoms are not fully surrounded by other adsorbent atoms. This energy, of approximately the same magnitude as Van der Waal's bonds, is the attractive force. Because no chemical bonds are formed, the process is generally reversible. Desorption, the reverse process, can easily occur under the correct conditions.

Granular activated carbon, which was developed in 1941 for use in gas masks, is prepared from coal, wood, or other carbon sources under elevated temperatures and in a controlled atmosphere (Gentry and Dean 1984). Commercially available grades have surface areas of 500 to 1400 m^2/g (270,000 to 760,000 yd^2/lb). Most of this surface area is necessarily contained in interior pores. The surface area and pore size distribution for a GAC are usually determined by a comparison of the quantity of water or mercury adsorbed at various pressures.

The adsorptive capacity of GAC for each contaminant of interest may be determined by a laboratory test resulting in an isotherm. Three significant problems should be noted when using an isotherm to predict carbon usage. First, by definition an isotherm is considered strictly valid only at the temperature at which the test was conducted (Dobbs and Cohen 1980). Second, the tests are run in the absence of other contaminants. Competitive adsorption by even traces of another contaminant can greatly reduce the adsorption rate or capacity. Third, the isotherm represents the amount of contaminant the GAC can adsorb at equilibrium. Isotherms can be useful in calculating the effective life of a GAC unit; however, the limitations must be kept in mind. In an EPA publication entitled "Carbon Adsorption Isotherms for Toxic Organics," Dobbs and Cohen (1980) presented laboratory-generated isotherms for many compounds found at Superfund sites.

Contact time is the most important design consideration for a carbon adsorption system (Gentry and Dean 1984). This is not the "superficial contact time," i.e., the volume of carbon divided by the water flow rate. The contact time used for this purpose is one-half of the superficial contact time and is designated the "real contact time" (Gentry and Dean 1984).

When the effluent from the first unit (see Figure 1b) reaches a maximum allowable concentration, the carbon unit is removed and the second unit is rotated into its place. A new carbon unit is then inserted at the end of the two unit series. This method ensures that the carbon usage is maximized before the unit is removed. The GAC units used in POE treatment always contain virgin carbon. The used carbon from the POE units may be regenerated, but it is then used for another purpose, e.g., at a wastewater treatment plant.

The primary reason for installing a POE treatment unit at an individual household is to protect the occupants from the health risks posed by exposure to the contaminants of concern; therefore, these units must be operated in a conservative manner. This conservative approach means that a carbon unit is sometimes replaced before it is completely spent to maximize protection from contaminant exposure.

Several methods are currently being used to determine when to replace GAC filters at sites where the influent contaminant concentrations at an individual well do not fluctuate much or they generally decrease with time. Carbon replacement times are based on contaminant loading, estimated waterflow, and the theoretical isotherm for the carbon and the major contaminant. A breakthrough time for the first carbon unit is calculated, and a safety factor is typically added to assure that the unit is replaced before breakthrough occurs. In Region 3 and the State of Florida (where this situation exists), replacement of carbon units is scheduled on a quarterly and semiannual basis, respectively. Quarterly monitoring is practiced in both places to verify the integrity of the treatment systems.

At the Olean Site in Cattaraugus County, New York, contaminant concentrations have varied greatly at individual wells. Households with POE treatment systems are monitored quarterly, and detailed records are kept of waterflow through the systems. A new isotherm is calculated for an individual system each time samples are collected to take the high contaminant load variability into consideration. Thus, the carbon replacement times are determined individually based on monitoring and waterflow measurement.

A similar approach is practiced for installations in Region 5; carbon replacement is based on water monitoring results. Samples are collected on a quarterly basis and flow through the treatment system is recorded with a

flowmeter. Carbon units are replaced when breakthrough is detected in the first unit. To date, only 1 of the 54 units has experienced breakthrough; the systems have been operating since 1986.

Cobiella (EPA 1984) developed "An OSC's Guide to Point-of-Use Activated Carbon Systems Preliminary Design" based on field experience with whole-house water treatment units at the Olean Site in Region 2. This document describes the decisions that were made in the design of the POE system and provides details on how the systems were sized for the individual locations. The document is presented in Appendix C.

The New York State Department of Health, Division of Environmental Protection, also developed a guide entitled "Interim Report, Point-of-Use Activated Carbon Treatment Systems," December 1982. This document provides information and general guidance for the design of POE GAC systems.

3.2 AIR STRIPPER SYSTEMS

Air stripping (or aeration) is another technique used to remove VOCs and petroleum products from a water stream. Air stripping also effectively removes radon from contaminated water. Two aeration methods have been applied in POE treatment: packed-tower aeration and diffused bubble aeration. The principle of aeration is to provide enough contact between the water and air to allow the VOCs solubilized in the water phase to transfer to the gas phase. The air will then carry off the contaminants. The ability of a compound to be stripped from the water is directly related to its Henry's Law Constant. Figure 2 shows a comparison of the Henry's Law Constants for selected organics.

Packed-tower aeration involves spraying the contaminated water over an inert packing. The water flows down through the packing as clean air is blown up through the packing. The air will have transferred the VOC contaminants to a vent outside the house. The treated water is collected and is available for use in the household water system. A schematic of a packed-tower system is provided in Figure 3.

A diffused aeration system involving a multistage flow pattern has been developed (Lowry 1985). Six separate vessels connected in series provide complete mixing during aeration. Figure 4 presents a schematic diagram of the Lowry system.

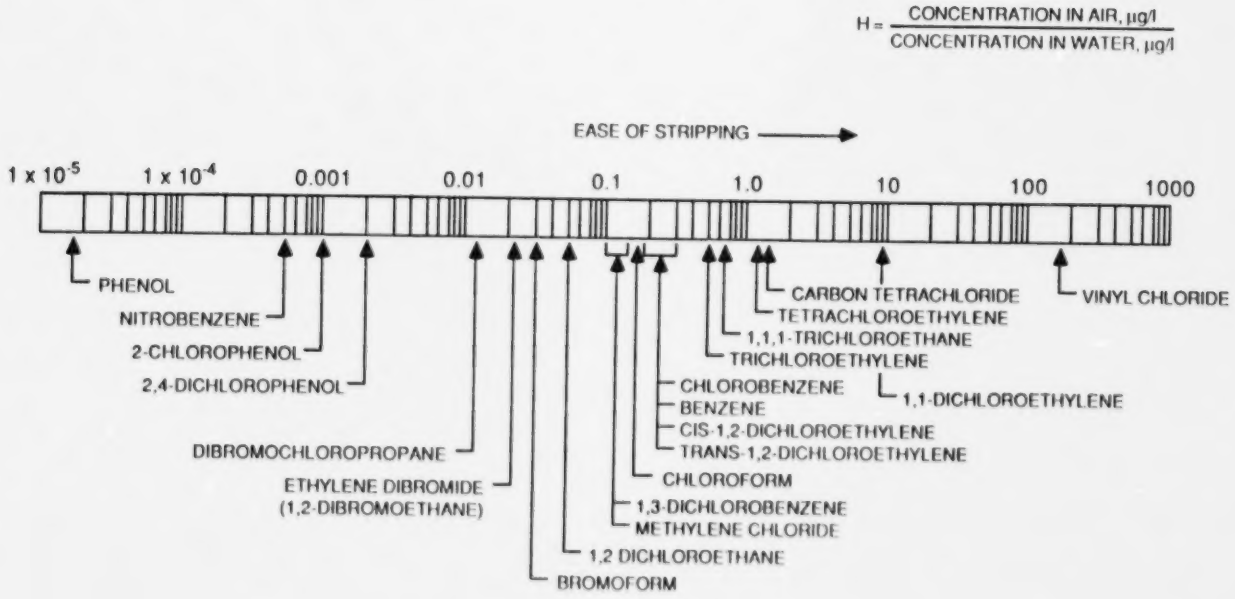

Figure 2. Comparison of Henry's Law Constants for Selected Organics

Source: Calgon Carbon Corporation, Pittsburgh, PA.

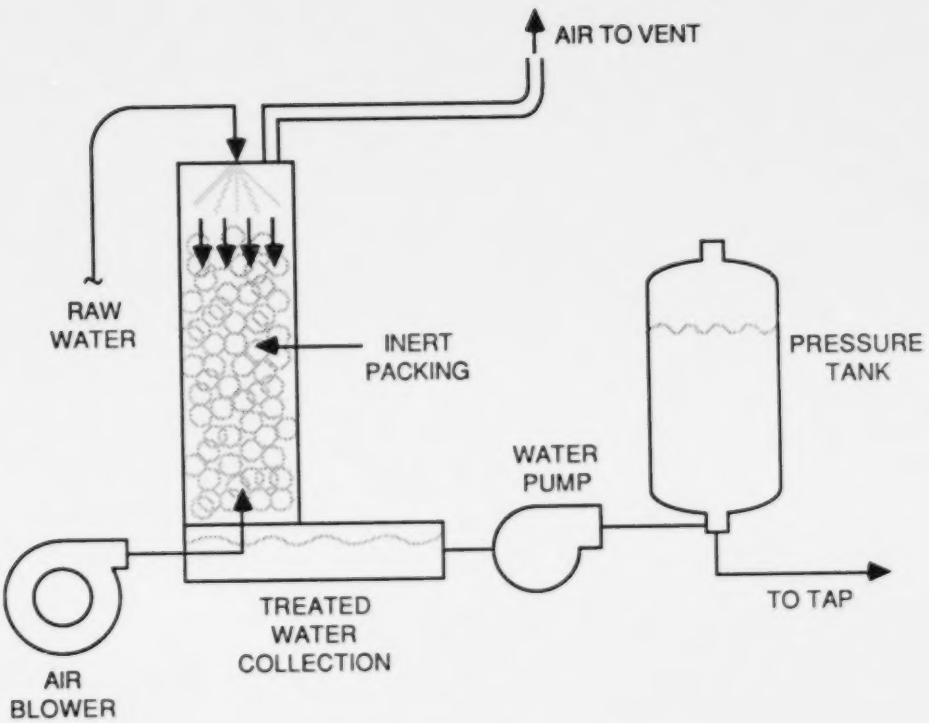

Figure 3. Schematic of a packed tower aeration system.

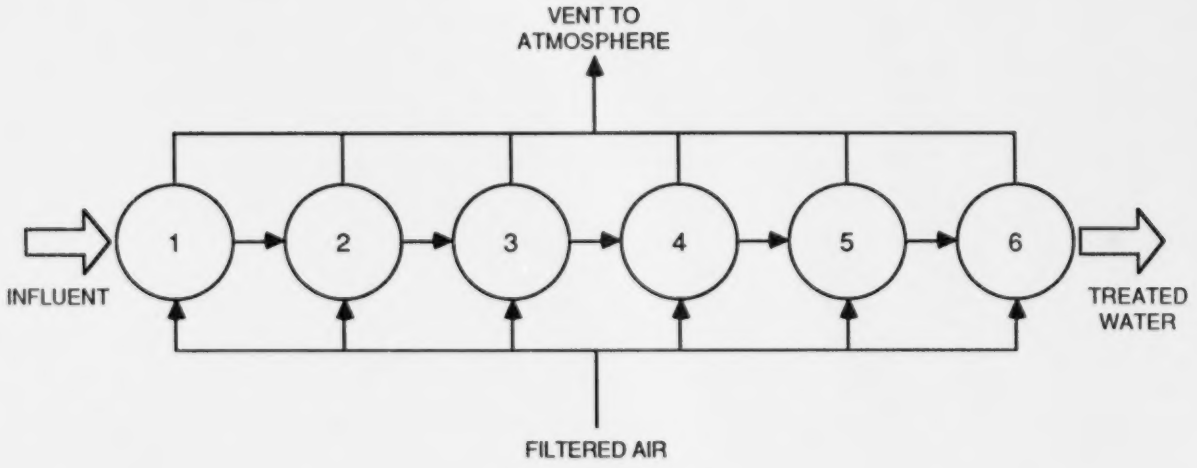

Figure 4. Schematic of Lowry's diffused aeration system (Lowry 1985).

Findings of this study indicate that POE systems based on aeration are more effective in treating water contaminated with petroleum products than are POE systems based on GAC. The GAC units quickly become saturated during the treatment of water contaminated with petroleum products and must be changed frequently to attain adequate treatment levels. Saturation is not a problem with aeration systems; therefore, they are very useful in treating petroleum products contamination.

As mentioned earlier, aeration has also proven to be effective in treating radon-contaminated water. The radon is evaporated and vented outside the house. Granular activated carbon also has been used to treat radon contamination. Problems associated with radioactive byproduct buildup, saturation, and unit disposal, however, make aeration the more attractive treatment alternative. Lamarre (1988) and Jerry Lowry (personal communication, March 1988) are conducting research and product development in the area of POE aeration systems for radon treatment.

Aeration System Design Features

Region 5 of the EPA is studying the effectiveness of air stripping for POE application at a Superfund site. The system being tested consists of a 50-inch-high tower in which 1-inch-diameter polypropylene cylinders are used as the packing medium. The system is designed to handle a flow of 5 gpm and has an air-to-water ratio of 40:1. The Region 5 Technical Assistance Team is currently writing the report of the study results.

Operation and Maintenance

Operation and maintenance of the aeration systems centers around the mechanical parts of the system. The air pumps and water pumps require maintenance as directed by the manufacturer. Problems with the operation of these systems may result from scaling in the tower, inadequate water pressure, or poor operating conditions (such as freezing temperatures).

3.3 SYSTEM PERFORMANCE AND EFFECTIVENESS

The effectiveness of the POE treatment systems that have been installed at Superfund sites is measured by sampling the raw water and treated water and calculating the percent contaminant removed. Because, as previously stated, the primary goal of the treatment is usually to protect human health,

the systems are designed and operated to avoid the occurrence of breakthrough. This is especially true for a GAC unit system.

The monitoring data obtained during Phase I of this study generally reflect the goal of protecting against contaminant exposure. Table 3 presents a summary of monitoring data for the identified sites. The raw-water contaminant levels appear in the column labeled "Influent". The contaminant levels detected in the treated water are presented in the "Effluent" column. Many of the effluent levels were less than the detection limit and are indicated as below detection limit (BDL). The exact detection limits were not available in every situation.

The removal efficiencies provided by the various systems range between 86 and 99 percent. As shown, most of the systems are 99 percent or more effective. Some of the removal efficiencies were provided by the manufacturer.

3.4 RESIDUALS HANDLING AND DISPOSAL

Because POE treatment systems are being used to treat water with elevated levels of hazardous constituents from Superfund or comparable sites, residuals handling (i.e., saturated activated carbon and air emissions) can be a concern for the user. In the current applications of POE systems that were identified during this study, EPA, through Superfund monies, or a State or local agency, is overseeing the operation, maintenance, monitoring, and residuals handling for the individual systems. When Agency funding and participation end, however, these activities may be left up to the individual homeowners if continued treatment is necessary.

Based on current practice, just how the homeowner should handle operation and maintenance and, in particular, system monitoring and residuals disposal is not clear. The economy of dealing with the installation contractor for waste disposal may not be available to the individual homeowner, and the cost of sample analysis could well be prohibitive. These issues, which are critial for continued effective use of individual POE treatment systems, should be addressed in Phase II of this study so that useful guidance can be provided in a technical assistance document. Current residual handling and disposal practices are described here.

TABLE 3. SUMMARY OF EXISTING DATA FROM PHASE I OF POE WATER TREATMENT STUDY

Site name and location	POE system	Number of POE systems installed	Contaminants of concern	Influent, µg/liter	Effluent, µg/liter	Percent removal	Replacement period	Comments	Contacts
Petroleum product contamination sites, State of Maine	Diffused air stripping; includes six diffusion tanks (multi-stage)	100	Petroleum products, including gasoline and No. 2 fuel oil	175,000-350,000	<4	99	NA[a]		David Sait Maine DEP (207) 289-2651
Radon contamination sites, State of Maine	Air strippers; diffused air systems and packed tower systems	Unknown	Radon	400,000 pC/liter highest reported level	4,000-32,000 pC/liter	92-99 (reported)	NA	Air stripper systems for POE radon treatment are being tested by Lowry and Lamarre	1. Jerry Lowry Lowry Engineering (207) 948-3790 2. Bruce Lamarre Northeast Environmental Products (603) 448-3944
Suffolk County Water Treatment District, Suffolk County, New York	GAC filter (single unit). Contains 1 cf of GAC	3000	Aldicarb	7,500	<7	98	Based on monitoring	Treatment is discontinued when influent concentration of aldicarb is <7 ppb. Filter units have automatic backwash function to prevent clogging.	Dennis Moran Suffolk County Health Department (516) 348-2891
Olean Site, Cattaraugus County, New York	Two GAC filter units connected in series. Each unit has 1.5 to 2 cf of GAC.	37	TCE	1-3600	BDL[b]	98	Based on monitoring water flow	Because of the observed variability of the influent contaminant levels at the individual wells, isotherms are recalculated at each sampling round to predict carbon unit replacement period	1. Chester Halgas Cattaraugus County Health Department (716) 375-4121 2. Robert Cobiella EPA Region II (201) 321-6646
American Thermostat Site, Green County, New York	Two GAC filter units in series	6	PCE	690-79,500	BDL - 3	99	Unknown		Joe Ianotti New York DEC (518) 457-3296
Pompey Site, Onendaga County, New York	Air stripper	2	TCE t-1, 2-DCE 1,1-DCA	5 (see comments) 690 2	BDL BDL BDL	99	NA	Influent levels are the most recent high levels	Robert Cobiella EPA Region II (201) 321-6646
Deardorff Drive Site, York County, Pennsylvania	Prefilter, two GAC filter units in series, UV light	6	TCE	190-4,600	BDL	99	Quarterly	GAC filters contain 1.5 to 2.0 cf of activated carbon	Gerald Heston EPA Region III (215) 597-9355 (contact for all Region III sites)

(continued)

TABLE 3 (continued)

Site name and location	POE system	Number of POE systems installed	Contaminants of concern	Influent, µg/liter	Effluent, µg/liter	Percent removal	Replacement period	Comments	Contacts
Cryochem Ground-water Site, Berks County, Pennsylvania	Prefilter, two GAC filter units in series, UV light	13	DCE TCE PCE DCA 1,1,1-TCA	25-1,700 1-18 2-12 4-50 20-570	BDL BDL BDL BDL BDL	99	Quarterly	GAC filters contain 1.5 to 2.0 cf of activated carbon	
Adamstown Site, Adamstown, Maryland	Prefilter, two GAC filter units in series, UV light. Airstripper used as pretreatment in some cases.	18	TCE 1,1,1-TCA 1,1-DCA 1,1-DCE	2-520 2-51,000 2-210 3-570	BDL BDL BDL BDL	98-99	Quarterly for carbon cell	1,1,1-TCA is not completely removed by the double carbon filter system. Pretreatment with airstripper used to reduce VOC load and extend life of carbon filters.	
Hereford Township Groundwater Site, Berks County, Pennsylvania	Prefilter, two GAC filter units in series, UV light.	15	TCE PCE	20-22,900 1-1000	BDL BDL	99	Quarterly		
North Road Site, Jackson and Pocono Townships, Monroe County, Pennsylvania	(1) Airstripper (2) Prefilter, carbon cell, UV light	22	TCE 1,2-DCE PDE	10-7,000 10-290 20-30	BDL BDL BDL	Air stripper about 86 to 90% efficient. Total system shows ~99.9%	Quarterly for carbon cells		
EDB Program, Polk and Jackson Counties, Florida	Prefilter, two GAC filter units in series, UV light	850	Ethylene dibromide (EDB)	0.5-800	BDL	93	Semiannual	Carbon filters contain 1.5 to 2.5 cf of activated carbon.	Julie Gissendanner Florida DER (904) 487-3299
Non-EDB Program, State of Florida	Two carbon cells	11	Benzene Ethyl benzene Toluene Total xylene Naphthalene 1,2-DCA Total hydrocarbons	210 38 8 63 12 89 228	No monitoring data available at present. Only one sampling round has been conducted.	NA	Semiannual	Most of the contaminants are a result of gasoline contamination. In several cases, prefilters were added because of high iron content in the water.	

(continued)

TABLE 3 (continued)

Site name and location	POE system	Number of POE systems installed	Contaminants of concern	Influent, µg/liter	Effluent, µg/liter	Percent removal	Replacement period	Comments	Contacts
Byron Johnson Salvage Yard Site, Byron, Illinois	Prefilter, two GAC filters in series	10	TCE PCE	50-500 6-130	BDL BDL	99.7	Flow-based calculation in conjunction with monitoring		Sheri Bianchin EPA Region V (312) 886-9537
Main Street Well Field Site, Elkhart, Indiana	Prefilter, two GAC filters in series.	60	TCE Carbon tetrachloride	<10-5,000 <10-7,500	BDL BDL	99	Flow-based calculation in conjunction with monitoring.		Kenneth Theisen EPA Region V (312) 336-1961
Industrial Excess Landfill Site, Uniontown, Ohio	Packed tower air stripper	9	Vinyl chloride Chloroethane	4-7 1-2	BDL BDL	86	NA		Julie Mathieson EPA Region V (312) 353-6756

[a] NA = Not available or applicable.

[b] BDL = below detection limit. The detection limit was not always reported with the monitoring data; therefore, the removal efficiencies are approximate.

Spent Activated Carbon Handling

In most of the current applications of GAC filters, spent carbon filters are handled by the installation contractor. When a filter is replaced, it is generally taken to the contractor's facility, where the carbon is removed from the pressure vessel. The removed carbon is stored on site until enough has accumulated to make regeneration cost-effective. The most common regeneration method is thermal treatment. Organic contaminants are destroyed by the high temperatures, and the carbon is reconditioned for further use. The regenerated carbon is usually sold to wastewater treatment plants.

When carbon regeneration is not an available option, the spent carbon units are sometimes disposed in permitted industrial landfills. Although the spent carbon has been determined to be a household waste and is thus exempt from RCRA regulations, careful disposal practices have been implemented.

The contractor for the State of Florida, Continental Water Systems, conducted a characterization study of used activated carbon from petroleum contaminated carbon. It was determined that the carbon is not ignitable (flashpoint greater than 60°C), not corrosive (pH between 6 and 8), not reactive (stable and nonexplosive), and not EP-toxic (Gann 1988). A Toxic Contaminant Leaching Potential (TCLP) test was also run on a sample of carbon taken from the top (the most contaminated part) of the first carbon unit (see Figure 1b). The TCLP test produced approximately 14 ppb total VOCs from the diesel-contaminated carbon (Gann 1988).

Air Stripper Emissions Control

The air strippers currently being used for POE treatment are located either in a basement or outside the house. All of the systems are vented outside so that emissions from the strippers are discharged to the ambient air. No other emission controls have been placed on these POE air strippers. The VOC concentrations in the air stripper emissions are low enough that further dilution in the ambient air appears to be adequate treatment to minimize human exposure to the VOCs.

3.5 POE SYSTEM COSTS

Several factors are involved in determination of the total cost of POE treatment systems. These include:

- Equipment costs
- Installation costs
- Maintenance costs
- Monitoring costs
- Residuals handling costs

In some cases a single contractor may provide all of these services, including sample collection, analysis, and reporting. Depending on the magnitude of a project, however, several contractors may be required. Monitoring may be handled by the EPA or a State or local agency.

Cost information for several of the existing POE applications is presented in the following subsections.

Byron Johnson Salvage Yard Site, Byron, Illinois

A phased feasibility study of remedial alternatives was conducted for this site in 1986. The proposed remedial action involved the installation of 110 individual GAC treatment units. The cost data presented in Table 4 are taken from the record of decision.

State of Florida Ethylene Dibromide Program

The Florida Department of Environmental Regulation (FDER) has overseen the installation of more than 800 POE GAC treatment systems to deal with an extensive ethylene dibromide (EDB) contamination problem. In providing the POE treatment units to the affected individuals, FDER has procured one contractor to design, obtain, install, and maintain the systems. The contractor also handles all residuals management, as described in Section 3.4. The FDER collects and analyzes samples to monitor system performance and effectiveness.

In 1987, FDER did a present worth evaluation for the EDB Program GAC filter installation. The results are summarized in Table 5.

TABLE 4. COST DATA FOR POE GAC UNITS AT THE BYRON JOHNSON SALVAGE YARD SITE, BYRON, ILLINOIS[a]

Capital Cost	
Carbon filter, chlorinator, mixing tank ($800/unit, 110 units)	$88,000
Installation ($250/unit, 110 units)	27,500
Total Capital Cost = A	$115,500
Annual Cost	
Project administration	7,000
Replacement filters ($200/unit, semiannually)	44,000
Total	$51,000
Monitoring Program	
5-year duration	$23,200
7-year duration	$17,000
20-year duration	$6,800
Present worth of annual cost[b] = B	
5-year duration	$281,300
7-year duration	$331,000
20-year duration	$492,100
Total present worth cost = A + B	
5-year duration	$396,800
7-year duration	$446,500
20-year duration	$607,600

[a] Source: EPA (1986).

[b] 10 percent discount rate; no escalation.

TABLE 5. PRESENT WORTH EVALUATION FOR GAC FILTER INSTALLATION (ANALYSIS FOR AN INDIVIDUAL SYSTEM)[a]

Capital cost	
Carbon filters (2), prefilter, UV light	$1,000
Annual maintenance and replacement	852
Quarterly sampling and analysis	400

Present worth for 10 years (8 percent interest)

	Without sampling	With sampling
3% inflation	$7,579	$10,668
5% inflation	8,268	11,680
7% inflation	9,069	12,858

Present worth for 20 years (8 percent interest)

	Without sampling	With sampling
3% inflation	$11,618	$16,602
5% inflation	13,675	19,626
7% inflation	16,375	23,594

[a] Source: Dykes (1987).

SECTION 4

SUMMARY AND RECOMMENDATIONS

4.1 PHASE I FINDINGS

Phase I data collection activities have resulted in the following general findings:

- Existing Superfund applications of POE treatment systems are primarily located in EPA Regions 2, 3, and 5.
- State and local agencies in Florida, Maine, New York, and New Jersey are also applying POE water treatment at comparable sites.
- The application of POE treatment has occurred primarily at sites where organic contamination (i.e., chlorinated solvents, pesticides, and petroleum products) has affected drinking water supplies.
- Granular-activated-carbon (GAC) filters and air stripping are the two most common POE technologies used for treating organic contaminants.
- The use of GAC filters, either single units or two units in series, is successful in treating water contaminated with chlorinated solvents and pesticides.
- Air stripping, either diffused or packed-tower aeration, is more effective than GAC for treating water contaminated with petroleum products.
- In some cases, air stripping is used in series operation for water with elevated levels of solvents before the water passes through a GAC filter. This is done to extend the effective life of the carbon filter.
- On individual wells where radon contamination is a problem, POE treatment with air stripping is currently being used.

4.2 DATA QUALITY AND COMPLETENESS

Most of the existing Superfund applications of POE water treatment were identified during this phase of the study. Some information relative to system design and operation also was identified; however, the level of detail of the design information (i.e., unit specifications) is somewhat lacking. System suppliers and designers have been either reluctant or unable to provide the type of information needed. Many are small operations with limited personnel and financial resources available for organizing and presenting the requested data.

In most cases, no quality control (QC) data for analytical data obtained during Phase I were available, including test methods, protocols and QC samples. Some samples were analyzed by field gas chromatographs to determine the presence or absence of contaminants. Although these data are useful for the system monitors to determine contaminant exposure, they may not provide the level of confidence required for the development of a technical assistance document.

4.3 RECOMMENDATIONS

Although the POE systems being applied at Superfund or comparable sites are effectively treating the contaminants of concern, the design, development, operation, maintenance, and monitoring of these systems varies from site to site. Evaluation of the data from these sites has shown inconsistencies or variations in system applications making it apparent that additional study of POE water treatment systems is necessary to develop a standard technical assistance document. Because most of the existing data and field experience related to POE water treatment are concerned with GAC filters and air strippers for treatment of organic contaminants, it is recommended that further detailed study center around these two technologies for treatment of organics.

The technical assistance document should provide EPA and State Superfund personnel with specific guidance on selecting, operating, and maintaining an effective POE water treatment system. The following questions address technical issues on which the document user may need specific guidance:

- What design flow requirements should be used for operating the POE system? For instance, should the flow be based on an assumed water usage rate for a household or a per capita usage rate? What are the minimum, maximum, and average flow requirements for the system?

- What are the sampling points of interest for the POE treatment systems? Is it sufficient to measure only raw and treated water (to measure system effectiveness) or is sampling between GAC filters necessary (to measure filter longevity and efficacy)?

- Is there a design life for activated carbon for the contaminants of concern? What is the effect of contaminant mixtures on carbon life?

- Is it more cost-effective to change activated carbon frequently or to sample and analyze to monitor for breakthrough (cost of GAC versus sampling and analysis)?

- Should the POE system be designed for a certain physical size, area, or volume (considering space restrictions in homeowners' basements or lack of a basement)?

- Should the POE system have a standard size so a series of GAC units could be used for treating ground water with a high contaminant load?

- Is there a minimum contact time for raw water with GAC or air stripping systems?

- What properties of activated carbon are critical in designing a POE treatment system (e.g., pore size, carbon mass, particle size, etc.)?

- Do other ground-water constituents affect GAC filter or air stripper effectiveness or operation (e.g., dissolved solids, pH, heavy metals, hardness)?

- What regulatory restrictions apply to the disposal of spent activated carbon or air emissions from an air stripper?

- How can an individual homeowner ensure effective operation of a POE treatment system? Is sampling and analysis necessary? Where can spent activated carbon from a POE Superfund application be disposed of or regenerated at a reasonable cost?

These issues, which may be contaminant and/or site dependent, should be considered when designing a POE treatment system demonstration for Phase II of this study.

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U.S. Environmental Protection Agency. 1986. Record of Decision, Remedial Alternative Selection, Byron Johnson Salvage Yard Site, Byron, Illinois.

APPENDIX A

REGIONAL, STATE, AND LOCAL AGENCY CONTACTS AND LIST OF MANUFACTURERS AND SUPPLIERS

EPA Regional Contacts

Region	Name, Organization, Phone
1	David Tordoff Environmental Services Division, Oil and Hazardous Materials (617) 860-4362
2	Robert Cobiella Emergency Response, Site Mitiation Section (201) 321-6646
3	Gerald Heston Superfund, Emergency Response Section (215) 597-9355
4	Jan Rogers Emegrgency and Remedial Response Branch (404) 347-3931
5	Sheri Bianchin Public Water Supply, POE Treatment (312) 886-9537
5	Kenneth Thiesen Superfund, Emergency Response (312) 886-1961
6	Charles Gazda Emergency Response Section (214) 655-2270
7	Charles Hensley Emergency and Remedial Response (913) 236-3888
8	Jack Hoffbuhr Emergency and Remedial Response (303) 294-7515

EPA Regional Contacts

Region	Name, Organization, Phone
9	Terry Brubaker Superfund, Emergency Removal (415) 974-7511
10	Robert Stamnes Emergency Response (206) 442-1512

State Contacts

State	Name, Organization, Phone
Maine	David Sait Department of Enviornmental Protection, Water Supply (207) 289-2651
New York	George A. Stasko Department of Health, Public Water Supply (518) 458-6731
New Jersey	Kim Friedman Department of Environmental Protection, Bureau of Water Supply (609) 984-5862
Florida	Glenn M. Dykes, P.E. Department of Environmental Regulation (904) 487-3299
Ohio	David Strayer Ohio EPA, Corrective Action Section (614) 481-7207
Illinois	Steve Colantino Illinois EPA, Land Pollution Control (217) 785-3497

Local Contacts

Location	Name, Organization, Phone
Suffolk County, New York	Dennis Moran Department of Health (516) 348-2891
Cattaraugus County, New York	Chester Halgas, P.E. Department of Health (716) 375-4121

Local Contacts

Location	Name, Organization, Phone
Washington Township, New Jersey	Christianna Cooke Washington Township Health Department (201) 876-3650
North Haledon Borough, New Jersey	Lucille Dibiak North Haledon Borough Clerk (201) 427-7793
Hopewell Township New Jersey	John Racioppi Hopewell Township Department of Health (609) 737-0120

LIST OF MANUFACTURERS AND SUPPLIERS

Manufacturer/supplier	Product
Bruner Corporation Jim Tishioni (414) 747-3700	Carbon filter units
Calgon Corporation Robert Deithorn (412) 787-6814	Activated carbon
Continental Water Services Dale Gann (904) 376-7833	Carbon filters, UV light systems
Culligan International 1/800-451-3260	Carbon filter manufacturer and supplier
Lowry Engineering Jerry Lowry (207) 948-3790	Air stripper designer/manufacturer
North American Aqua Rocco Papendreas (616) 476-2092	Carbon filter systems
Northeast Environmental Products Bruce Lamarre (603) 448-3944	Air stripper designer/manufacturer
TYKK Tom Yohe (215) 525-1400	Air stripper manufacturer

APPENDIX B

SUBSTANCES FOUND AT PROPOSED AND FINAL NPL SITES

October 1986
(List developed by US EPA Office of Emergency and Remedial Response)

Chemical Name	Frequency
Trichloroethylene (TCE)	311
Lead (Pb)	286
Toluene	243
Chromium and compounds, NOS (Cr)	220
Benzene	208
Chloroform	179
Polychlorinated Biphenyls, NOS	159
1,1,1-Trichloroethane	151
1,1,2,2-Tetrachloroethene	149
Zinc and compounds, NOS (Zn)	142
Cadmium (Cd)	141
Arsenic	141
Phenol	121
Xylene	113
Ethyl benzene	111
Copper and compounds, NOS (Cu)	106
1,2-trans-Dichloroethylene	104
Methylene chloride	91
1,1-Dichloroethane	85
1,1-Dichloroethene	79
Mercury	78
Cyanides (Soluble Salts), NOS	73
Vinyl chloride	70
Nickel and compounds, NOS (Ni)	65
1,2-Dichloroethane	64
Chlorobenzene	64
Carbon tetrachloride	61
Heavy metals, NOS	56
Pentachlorophenol	53
Naphthalene	48
Methyl ethyl ketone	42
Trichloroethane, NOS	38
Iron and compounds, NOS (Fe)	33
Barium	32
Volatile organics, NOS	31

(continued)

(continued)

Chemical Name	Frequency
Manganese and compounds, NOS (Mn)	31
Acetone	30
Phenanthrene	28
Benzo-a-pyrene	27
Chromium, hexavalent	27
1,1,2-Trichloroethane	25
Arsenic and compounds, NOS (As)	25
Dichloroethylene, NOS	24
DDT	22
Styrene	22
Anthracene	22
Lindane	21
Bis(2-ethylhexyl)phthalate	21
Tetrachloroethane, NOS	21
Selenium	20
1,1,2,2-Tetrachloroethane	19
Creosote	19
Pyrene	19
Waste oils/sludges	18
Sulfuric acid	18
Aluminum and compounds, NOS (Al)	18
Acid, NOS	17
Benzo-(j,k)-fluorene	17
Fluorene, NOS	17
Radium and compounds, NOS (Ra)	16
Trichlorofluoromethane	15
Asbestos	15
Dichloroethane, NOS	15
Acenaphthene	14
Cis-1,2-dichloroethylene	14
Ethyl chloride	14
Chlordane	13
Trinitrotoluene (TNT)	13
Uranium and compounds, NOS (U)	13
Antimony and compounds, NOS (Sb)	13
Hexachlorobenzene	12
Di-n-butyl-phthalate	12
Radon and compounds, NOS (Rn)	12
Ammonia	12
Dichlorobenzene, NOS	12
Tetrahydrofuran (I)	11
Chloromethane	11
Methyl isobutyl ketone	10

(continued)

(continued)

Chemical Name	Frequency
Chrysene	10
Tetrachloroethene, NOS	10
Dioxin	10
DDE	10
Pesticides, NOS	9
Waste solvents	9
Hexachlorocyclopentadiene (C56)	9
2,4-Dinitrotoluene	9
1,4-Dichlorobenzene	9
Dieldrin	9
Nitrates, NOS	9
Dibromochloromethane	9
Thorium and compounds, NOS (Th)	9
Hydrocarbons, NOS	9
Tribromomethane	8
Ethyl ether	8
2,6-Dinitrotoluene	8
Diethyl Phthalate	8
1,2-Dichlorobenzene	8
Cresols	8
Bromomethane	8
RDX	8
Fluoride, NOS	8
Chlorinated hydrocarbons, NOS	8
1,1,2-Trichloro-1,2,2-trifluoroethane	8
Beryllium and compounds, NOS (Be)	8
Waste lacquer/paint	7
Grease and oil	7
Hexachlorobutadiene (C46)	7
1,2-Dichloropropane	7
Heptachlor	7
Endrin	7
Aldrin	7
Boron and compounds, NOS (B)	7
DDD	6
Silver	6
Trichlorophenols, NOS	6
Chromium, trivalent	6
Phthlates, NOS	6
Dibenzofuran	6
Chloride (ion)	6
Coal tars	6
1,2,3-Trichloropropane	6
Methanol	5

(continued)

(continued)

Chemical Name	Frequency
2,4-Dimethylphenol	5
Dichlorodifluoromethane	5
1,3-Dichlorobenzene	5
Cyclohexane	5
Bis(2-chloroethyl)ether	5
Benzo-(a)-anthracene	5
Acrolein	5
m-Xylene	5
Trimethyl benzene	5
Phosphoric acid	5
Acenaphthylene	5
Halogenated solvents, NOS	5
Chromic acid	5
Methane	5
Sulfate (ion)	5
Cobalt and compounds, NOS (Co)	5
1,2,4-Trichlorobenzene	5
1,3,5-Trinitrobenzene	4
Nitrobenzene	4
Hydrogen Sulfide	4
1,2-Dibromo-3-chloropropane	4
Cumene	4
2-Chlorophenol	4
Calcium chromate	4
Toxaphene	4
Sodium cyanide	4
Methylnaphthalene	4
Trichlorobenzene	4
Halogenated organics, NOS	4
Hexachlorocyclohexane, NOS	4
Nitric acid	4
Sodium hydroxide	4
Hydrochloric acid	4
n-Pentane	4
Hexane	4
n-Heptane	4
n-Nitrosodiphenylamine	4
Bromodichloromethane	4
Polynuclear aromatic hydrocarbons	3
2,4,5-TP (Silvex)	3
2,4,5-T	3
Resorcinol	3
4-Nitrophenol	3
Formaldehyde	3
1,2-Diphenylhydrazine	3

(continued)

(continued)

Chemical Name	Frequency
Di-n-octyl phthalate	3
2,4-Dichlorophenol	3
p-Chloro-m-cresol	3
Benzidine	3
Aniline	3
Fluorine (F)	3
Endosulfan	3
Beryllium dust, NOS	3
Arsenic trioxide	3
1,2-Dichloroethene	3
Dinitrotoluene, NOS	3
Sulfates, NOS	3
Aliphatic hydrocarbons, NOS	3
Mirex	3
Octane	3
Vanadium and compounds, NOS (V)	3
Tin and compounds, NOS (Sn)	3
Magnesium and compounds, NOS (Mg)	3
Titanium and compounds, NOS (Ti)	3
Nitrophenol, NOS	3
Isopropanol	3
Isophorone	3
Ethylene glycol	3
Ethanol	3
Butadiene	3
Adipic Acid	3
Selenium and compounds, NOS (Se)	3
Phthalic esters, NOS	3
Halomethane, NOS	3
Benzo-(b)-fluoranthene	3
Barium and compounds, NOS (Ba)	3
Mineral spirits	2
Plating sludges	2
Nonvolatile organics, NOS	2
Alcohol, NOS	2
Methoxychlor	2
2,4,5-Trichlorophenol	2
Toluene diisocyanate	2
Pentachlorobenzene	2
Methyl methacrylate	2
4,4'-Methylene-bis-(2-chloroaniline)	2
Hydrofluoric acid	2
Hexachloroethane	2
Ethyl acetate	2
1,4-Dioxane	2

(continued)

(continued)

Chemical Name	Frequency
Dimethyl phthalate	2
3,3'-Dichlorobenzidine	2
Cyclohexanone	2
1-Butanol	2
Bis(2-chloroethoxy)methane	2
Acrylonitrile	2
Phosgene	2
Parathion	2
2,4-Dinitrophenol	2
Benzyl chloride, NOS	2
Carbon disulfide	2
2,4-Dichlorophenoxyacetic acid	2
Dithiane, NOS	2
2,4,6-Trinitrotoluene	2
Diethylhexyl phthalate	2
Thiocyanates, NOS	2
Trinitrophenylmethylnitroamine	2
1,3,5-Trimethylbenzene	2
n-Butylbenzene	2
Tris, NOS	2
Phenol, Dichloro, NOS	2
3,4-Benzofluoranthene	2
Methylene chloroform	2
Nickel chloride	2
Plutonium 239	2
Tritium	2
1,2,4-Trimethylbenzene	2
Diacetone-alcohol	2
Atrazine	2
Propenylbenzene	2
Ketones, NOS	2
Olefinic hydrocarbons, NOS	2
Dimethylaniline	2
Pentachlorobutadiene	2
Polybrominated biphenyl (PBB), NOS	2
(p) Ethyl toluene	2
(p) Methyl styrene	2
Hypochloric acid	2
Bromochloromethane	2
Methylcyclohexane	2
Dimethyl formamide (DMF)	2
Zirconium and compounds, NOS (Zr)	2
Sulfur (Elemental - S)	2
Strontium and compounds, NOS (Sr)	2
Sodium and compounds, NOS (Na)	2

(continued)

(continued)

Chemical Name	Frequency
Phosphorus and compounds, NOS (P)	2
Phenolic compounds, NOS	2
Molybdenum and compounds, NOS (Mo)	2
Biphenyl	2
Sulfur Dioxide	2
4-Nitrotoluene	2
Nitrocellulose	2
Naphtha	2
Isopropyl ether	2
Dicyclopentadiene	2
Chlorodifluoromethane	2
4-Chlorophenol	2
Thallium and compounds, NOS (Tl)	2
Mustard gas	2
Aramite	2
Caustics, NOS	1
Brake fluid (Off-Spec.)	1
Glycols, mixed	1
Fungicides	1
Pyrethrum	1
Bearing packing	1
Plasticizers	1
No. 2 Fuel oil	1
Petroleum and petroleum distillates	1
Gasoline	1
Tris(2,3-dibromopropyl)phosphate	1
1,2,4,5-Tetrachlorobenzene	1
Pyridine	1
2-Methylpyridine	1
Phthalic anhydride	1
Pentachloroethane	1
n-Nitroso-n-methylurethane	1
Kepone	1
Hydrazine	1
Furfural	1
3,3'-Dimethoxybenzidine	1
1,2-Dibromoethane	1
Dibenz(a,h)anthracene	1
4-Chloro-2-methylbenzenamine	1
2-(Chloromethyl)oxirane	1
Chlorobenzilate	1
Chloral	1
(Trichloromethyl) benzene	1
Acetophenone	1
Acetronitrile	1
Acetaldehyde	1

(continued)

(continued)

Chemical Name	Frequency
Zinc cyanide	1
Sodium azide or smite	1
Potassium cyanide	1
Phorate	1
N-Nitrosodimethylamine	1
Nitroglycerine	1
2-Methylaziridine	1
Hydrocyanic acid	1
Aziridine	1
Disulfoton	1
Cyanogen	1
Copper cyanide	1
Barium cyanide	1
Ammonium picrate	1
Allyl alcohol	1
1-Acetyl-2-thiourea	1
Chromium	1
Nickel(II)acetate(1:2)	1
Decane	1
Benzothiazole	1
p-Dichlorobenzene	1
Cyclopropylbenzene	1
6-Methylheptylester-2 propenic acid	1
Triethyl phosphate	1
Allyl ether	1
p-Xylene	1
o-Xylene	1
Radioactive potassium	1
Sodium chromate (or dichromate)	1
1,2,3-Trimethylbenzene	1
2-Methylbutane	1
Dichloroethene, NOS	1
Bromodichloroethylene	1
Di-n-butyl phthalate	1
Americium	1
Oxathian	1
Ammonium nitrate	1
Carbofuran	1
Thiodan	1
Sodium dichromate	1
Quinoline	1
Copper chloride	1
p-Chlorophenylmethylsulfone	1
Diisopropylmethylphosphonate	1
2,4-Dimethyl-3-pentanone	1

(continued)

(continued)

Chemical Name	Frequency
Arochlor	1
Pentaerythritoltetranitrale	1
Methyl phthalates	1
Nickel sulfate	1
Zinc chloride	1
Copper hydroxide	1
Methyl ethyl pyridine	1
Vinyl pyridine, NOS	1
3,4-Dimethyl pyridine	1
Arsenic trisulfide	1
Octachlorocyclopentene	1
2,2'-Dichloro-n-methyl diethylamine	1

APPENDIX C

AN OSC's GUIDE TO POINT OF USE ACTIVATED CARBON SYSTEMS PRELIMINARY DESIGN

By Robert M. Cobiella, P.E.
U.S. Environmental Protection Agency
Region II Emergency Response

1.0 INTRODUCTION

After the start of Superfund removals activity, it soon became evident that groundwater contamination would be a difficult problem to solve. Home water supply wells were being found contaminated, presenting a hazard to human health by direct exposure of resident populations. The risk associated with contaminated well water involved not only uptake by direct ingestion, but also by skin contact and by inhalation, primarily associated with shower bathing. Ways had to be sought to reliably remove contaminants, primarily chlorinated solvents, from the typical household water supply.

Activated carbon treatment has long been used to remove chlorinated organics from water, but on a scale suited to industrial and municipal water supply and waste stream purification. Successful system design sizing for residential use was not a widely known process. One of the early NPL site applications of small point-of-use activated carbon treatment units was at Olean, N.Y. This essay will detail the design sizing process used for the second round of carbon treatment systems installations at Olean in mid 1984.

The systems installed at Olean were successful in risk mitigation terms, with contaminant strengths of treated water remaining consistently low. Not one of these systems has failed in 20 months of continuous service. As a result, the design configuration selected and the sizing process used is here strongly recommended for actions in which activated carbon treatment is the alternative of choice.

2.0 SMALL ACTIVATED CARBON SYSTEMS DESIGN DECISIONS

On the 19th and 20th of June 1984, a two day working session was held at the Cattaraugus County Department of Health in Olean, New York. At these meetings, treatment systems were sized for ten (10) of twelve (12) Olean water wells contaminated with trichloroethylene (TCE), and the systems' design details were agreed upon.

Present at these meetings were representatives of EPA, Cattaraugus County, O. H. Materials Company (EPA's ERCS contractor) and Pure Tech[1] (the subcontractor to ERCS).

Each contaminated location was assessed to determine the required carbon surface area and volume/weight. Criteria used for sizing were generally as presented in NYSDOH's (Division of Environmental Protection) interim report of December 1982 entitled, "Point-of-Use Activated Carbon Treatment Systems".

NYSDOH recommends that the following criteria be used as a basis for sizing:

1) That flow velocity through each carbon column be limited to ten (10) gallons per minute (gpm) per square foot.

2) That contact time (contaminated water time of contact with activated carbon) be a minimum of three minutes in each carbon column.

3) That only virgin carbon be used.

4) That disinfection be provided after carbon treatment.

5) That flow be meter recorded, sampled prior to and following treatment, adequately valved off and prefiltered, if necessary.

6) That the installation: allow easy unit changeout; be adequate to withstand peak system pressure; be made of non-toxic materials compatible with the contaminants; and be provided with gauges to measure pressure drop.

U.S. EPA Cincinnati was consulted by CCDOH by telephone. They recommended to the County that particulate filters or screens be installed and that units be cleared of transportable fines by purging them in reverse (backwash) flow prior to placing

[1] See listing, page 6.

them in service. They also suggested using an eight (8) minute contact time. This last suggestion was not adopted because it would provide minimal adsorptive improvement, and according to the OSC's calculations, would have doubled the carbon column costs, and the larger units in some cases would not have fit into the available space.

EPA's prior (1982) treatment system installations (16 units) at Olean had not shown any problem with bacterial colonies except in one location where the original installation had been erroneously cross-connected to a sanitary drain system. Elimination of the cross-connection had corrected the situation. As a result, the meeting agreed that no post-treatment or sterilization would be installed initially, that EPA would verify the biological quality of these water systems and that no automatic backwash would be used.

Prior experience in Olean also suggested that no screens or cartridge filters should be installed in relatively low demand systems, but that in-line cartridge filters would be needed in the higher demand systems at the two (2) trailer courts. These would be two (2) each in parallel between the pressure tank and the new water meter. Particulate filters for the low flow units were to be provided later if they proved necessary.

Agreement was also reached to install an automatic air (or vapor) eliminator on the high point of the raw water feed to the primary carbon column, in order to eliminate the possibility of air lock in the carbon bed, and to position the sample port between columns such that air bleed for the second unit would occur each time a sample set was taken.

All components of the piping systems were to be acceptable and approved for public water supply use.

The building inspector for the Town of Olean was consulted and requested that we get his approval of our materials, schematics and shop drawings for locations within the Town. O. H. Materials later accomplished this. The building inspector for the City of Olean was also consulted. Since only one residence was to be affected in the City of Olean, he did not require that we get his approval.

Site visits were made to all the potential installation sites to establish the suitability of each location for installation of carbon treatment systems. It was determined that:

a) No installation would be provided at Clean All Village because no human consumption of water, or showering, takes place on the premises.

b) No installation would be provided at Campbell's for the same reason as above.

c) Installations could and would be made indoors at each of the four (4) single residences, specifically at Zuckerman's, Douglas', Farber's and Hurlbert's. (Douglas' is also a realty.)

d) Installation could and would be made indoors at Sandburg Oil (in tight quarters).

e) Installations could not be accommodated indoors at Burton's Trailer Court and at Misiano and Coss (Trailer Court). Wooden outbuildings, insulated and heated, concrete floored and provided with locks, would be constructed to house the treatment systems. EPA, O. H. Materials and Pure Tech met with Mr. Burton and with Mr. Reynolds (of Misiano and Coss) and agreed on the installation details, routings and layouts for these two locations.

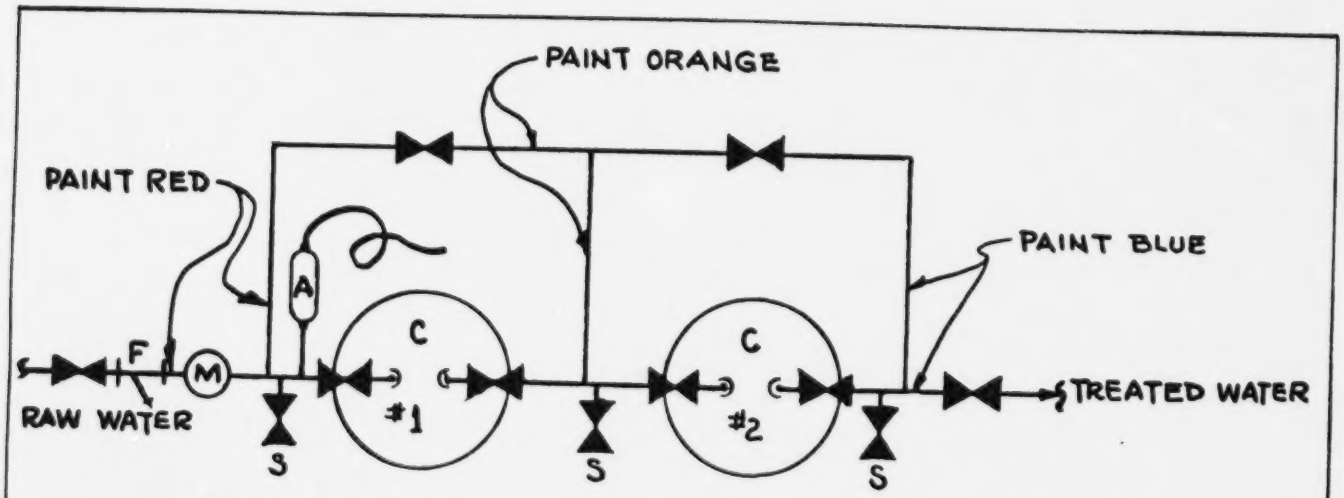
f) Installation could and would be made indoors at Scicchitano's three (3) dwelling unit structure.

g) The installation at Mastel Ford would be smaller and simpler than the others, and was feasible. This installation, since it was to treat only the water supply to one water cooler, would not be metered or provided with an air eliminator.

h) The installation at the Don Ra Tavern could and would be made indoors.

The above planned installations totaled ten (10) locations. Note that two (2) well systems of the twelve (12) originally considered had thus been disqualified by lack of a threat to human health. Two other private homes, Mr. Dave Torrey's home (Supervisor, Town of Olean) and Mr. Torrey's father's home, not included above, were not evaluated because the residents would not accept carbon treatment system installations, even though both wells were contaminated beyond NYSDOH guidelines.

As recommended by both the NYSDOH and the U.S. EPA Office of Research and Development, and as a result of the OSC's prior (5 breakthroughs) experience with 16 single column units at Olean, all installations would consist of two carbon columns in series except at Misiano and Coss, where two (2) sets of two (2) had to be provided to accommodate their high water demand. A schematic for these systems is attached.



A = AIR ELIMINATOR.
C = CARBON COLUMN.
F = PARTICULATE FILTER.
M = WATER METER.
S = SAMPLE TAP.

NOTE: IN AREAS HAVING HIGH COLIFORM COUNTS, AN ULTRAVIOLET STERILIZATION UNIT MAY BE REQUIRED AFTER C#2.

TYPICAL ACTIVATED CARBON TREATMENT SCHEMATIC AS INSTALLED AT OLEAN, N.Y.

Robert M. Colella, P.E. 6-20-84

The first (primary) activated carbon column in each series was area sized to take the system flow at 10 gpm per square foot and the carbon charge volume was sized so that replacement of the primary unit at 50% of theoretical breakthrough should not be necessary within the six month period following installation, even if variations in the observed contaminant levels should occur. Prior contaminant strengths found in these wells varied randomly, and it was expected that they would continue to do so. Recent samples had ranged between 67 and 1,200 ppb and averaged about 445 ppb. As a result of this uncontrolled variable, the lower concentrations at some locations yielded calculated breakthrough beyond 1,000 days of service for the primary column. The same sizing criteria yielded expected primary column breakthrough at 561 days at Burton's Trailer Park (440 ppb) and at 462 days at Misiano and Coss (1,200 ppb). Since TCE levels could not be accurately predicted, calculations were run at the contaminant strengths obtained from the latest round of samples and then the activated carbon depth for each unit was increased to protect against higher TCE contaminant strengths up to 600 ppb.

Water use was estimated conservatively, but this also was not truly applicable to any one specific dwelling. The same applied to peak instantaneous flow. As a result, some dwellings were expected at one time or another to use more water in less time than the figures arrived at. Conservative selection of carbon area and charge for the primary column might not in itself have been a foolproof guarantee in defense of public health. A second idential activated carbon column, provided in series with the primary unit, guarded against the above variables and against unexpected primary breakthrough or the sudden appearance of much higher TCE levels in the wells. Sampling to verify proper treatment unit operation and effectivity occurred at initial operation and at about 90 days into operation, using the Quality Assurance Plan approved for Olean in 1982.

EPA "removal action" involvement with these locations ended at the six month limit which exists for any individual "removal action" under CERCLA (in this case December 22, 1984), since field action began on June 19th. Maintenance and monitoring after that time was performed by the NYSDEC.

In summary, with the limited exceptions noted above, all recommendations made by NYSDOH were incorporated into these installations. In addition, the fines flushing procedure was performed on the smaller columns, the units were flushed in the normal flow direction, vibrated and vented to remove air, and all the household/dwelling taps were flushed simultaneously to eliminate contaminated water in the piping before normal consumption was resumed.

[1] List of attendees at the Cattaraugus County Department of Health meetings on June 19 and 20, 1984:

a) Mr. Chester R. Halgas, P.E., Director of Environmental Health Services, Cattaraugus County Department of Health.

b) Miss Lisa Napolione, Assistant to the Director, Cattaraugus County Department of Health.

c) Mr. John Bourret, Response Manager, O. H. Materials Company.

d) Mr. Chuck Huber, Pure Tech, Inc. Representative.

e) Mr. Robert M. Cobiella, P.E., OSC, U.S. EPA.

3.00 CALCULATIONS

I. BASIS

A. Flow - One home was assumed to consume 400 gallons per day (gpd) of wellwater. One trailer was assumed to use 250 gpd.

B. Peak Flow - One home was assumed to use an instantaneous peak flow of 5 gpm. One trailer was assumed to use 250/400 x 5 gpm.

C. Apartments were assumed to use 150 gpd per bedroom up to two bedrooms, and their instantaneous peak flow was calculated by flow ratio fractions of 5 gpm as in I-B above.

D. Column diameter selection was based on provision of at least one square foot (1 S.F.) of cross-sectional area for each ten gallons per minute of peak flow for one column.

E. Carbon bed depth was selected on a volume basis to provide at least three minutes of contact time at peak flow in each column. Bed depths for well-water systems currently exhibiting below average contaminant strengths were upgraded to allow for random contaminant strength variation.

F. Bed depths for residential systems were also evaluated to guarantee a minimum of six months of half-life for the primary column, such that no carbon changes would be required within the six-month Superfund "removal action" time limit.

G. Column carbon charges were selected generally in one (the next higher) cubic foot increments (25.3 lbs. per cu. ft.) in order to simplify field carbon charging to match the technical competence of labor. The exception to this rule was the case where maximum column carbon charge was needed and did not yield an even cubic footage.

H. The carbon adsorption isotherm used for original calculations was derived from the CCDOH experience with 16 carbon columns installed by EPA on well-water systems in this same general location in early 1982. Final calculation sheets for each system (Section 3.20) were subsequently modified to reflect adsorption isotherm figures from a NYSDOH publication, but proved to match the original numbers.

3.10 SAMPLE CALCULATION

A. User identification and address is made.

B. Type of facility is identified (i.e. single family dwelling, etc.).

C. Daily average flow and latest contaminant concentration for that location are identified.

D. Instantaneous (peak) water use in gpm is calculated.

E. A column diameter and bed depth are tentatively selected as per Section 3.00 A thru G, above.

F. Total carbon contaminant loading capacity (l) is determined based on contaminant strength, in ppb, from the isotherm graph, and on the weight of the carbon charge in each column. Thus, the isotherm loading in lbs. of contaminant per lb. of activated carbon, times the carbon charge weight per column, in lbs., equals the contaminant adsorption capacity (to "breakthrough") of that column.

G. Column longevity, in days, equals contraminant adsorption rate. In practice, the actual daily adsorption rate is pounds flow times [raw water total organic carbon (TOC) less treated water TOC], but since the isotherm used was field generated, it is acceptable to use pounds flow times TCE strength as a measure of daily adsorption. Thus, contaminant strength times daily flow, expressed in pounds per day, is taken here as the actual daily adsorption rate. This assumes that the column will produce effluent in which no TCE is present. So:

$$\frac{\text{gpd (ave)} \times \frac{62.4 \text{ lbs/cu.ft.}}{7.48 \text{ gals/cu.ft.}}}{\text{(TCE Strength in Decimal Form)}} = \text{Daily Rate (lbs/day)}$$

and column longevity, in days, is equal to total carbon contaminant loading capacity divided by the daily adsorption rate.

$$T(\text{Time in Days}) = \frac{L(\text{lbs})}{\text{Daily Rate (lbs/day)}}$$

H. Contact time (in minutes) is calculated on the basis of carbon bed void volume in cubic feet divided by the peak flow in cubic feet per minute. A column, loaded with three cubic feet of activated carbon, has a void volume of 0.8 x 3 = 2.4 cu.ft. assuming 80% voids[2]. If the peak flow through that column is 5 gpm, then minimum contact ime is equal to:

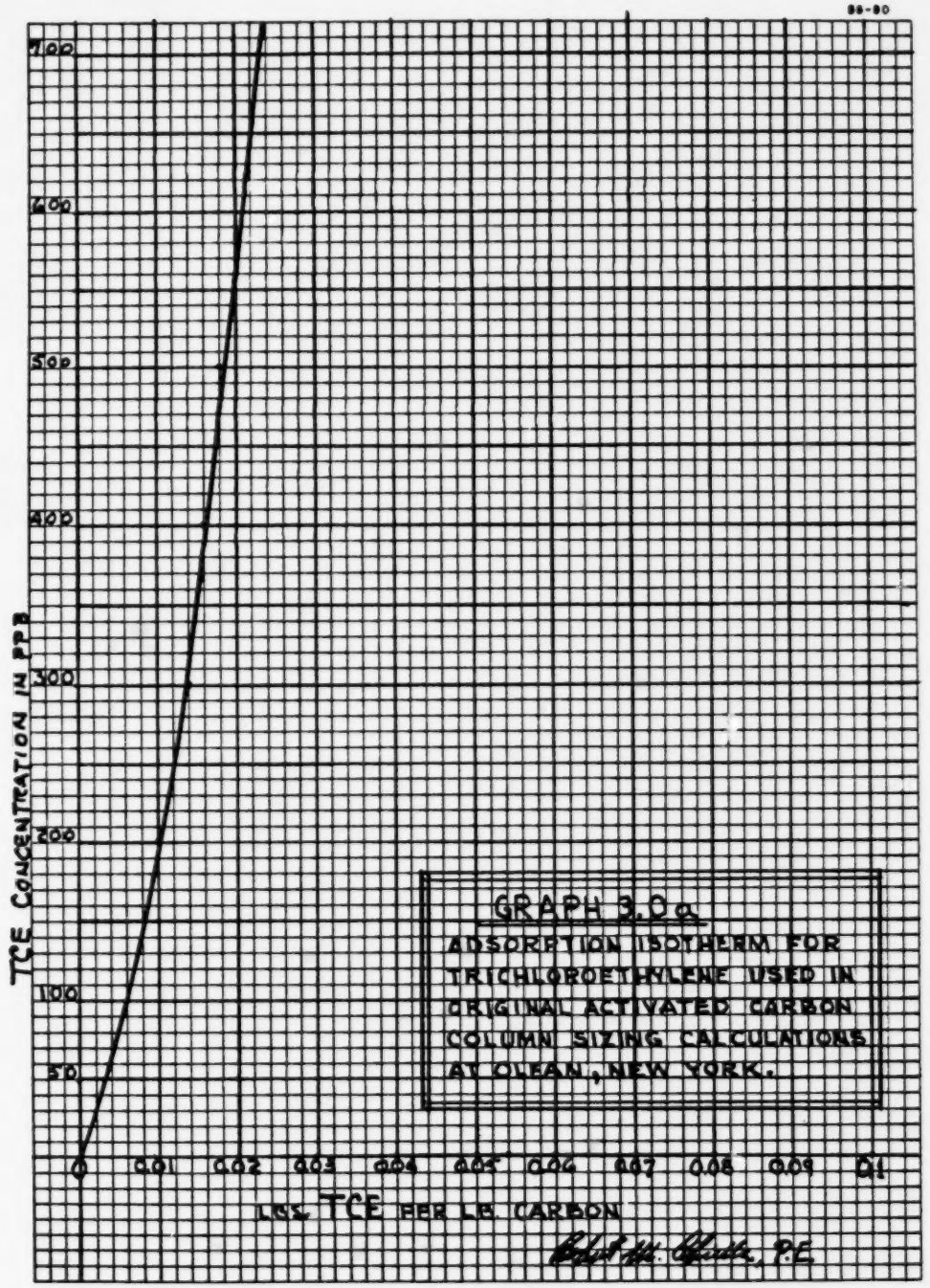
$$\frac{2.4 \text{ cu.ft.} \times 7.48 \text{ gals/cu.ft.}}{5 \text{ gals/min}} = 3.9 \text{ minutes}$$

It can thus be seen that 3 cu.ft. of granular activated carbon provides a minimum contact time of over 3 minutes/column in an average (5 gpm peak flow) homes. A 2 cu.ft. carbon charge will only yield 2.4 minutes contact.

3.20 SPECIFIC CALCULATIONS

Each individual installation was sized and evaluated per the sample calculations as described above. A set of these calculations for all Olean locations in the second phase of the immediate removal action follows.

[2] Average weight for carbon is 135 lbs./cu. ft., average weight for GAC is 25.3 lbs./cu.ft. and (135-25.3)135 = 0.813, or 81.3% (say 80%) voids.



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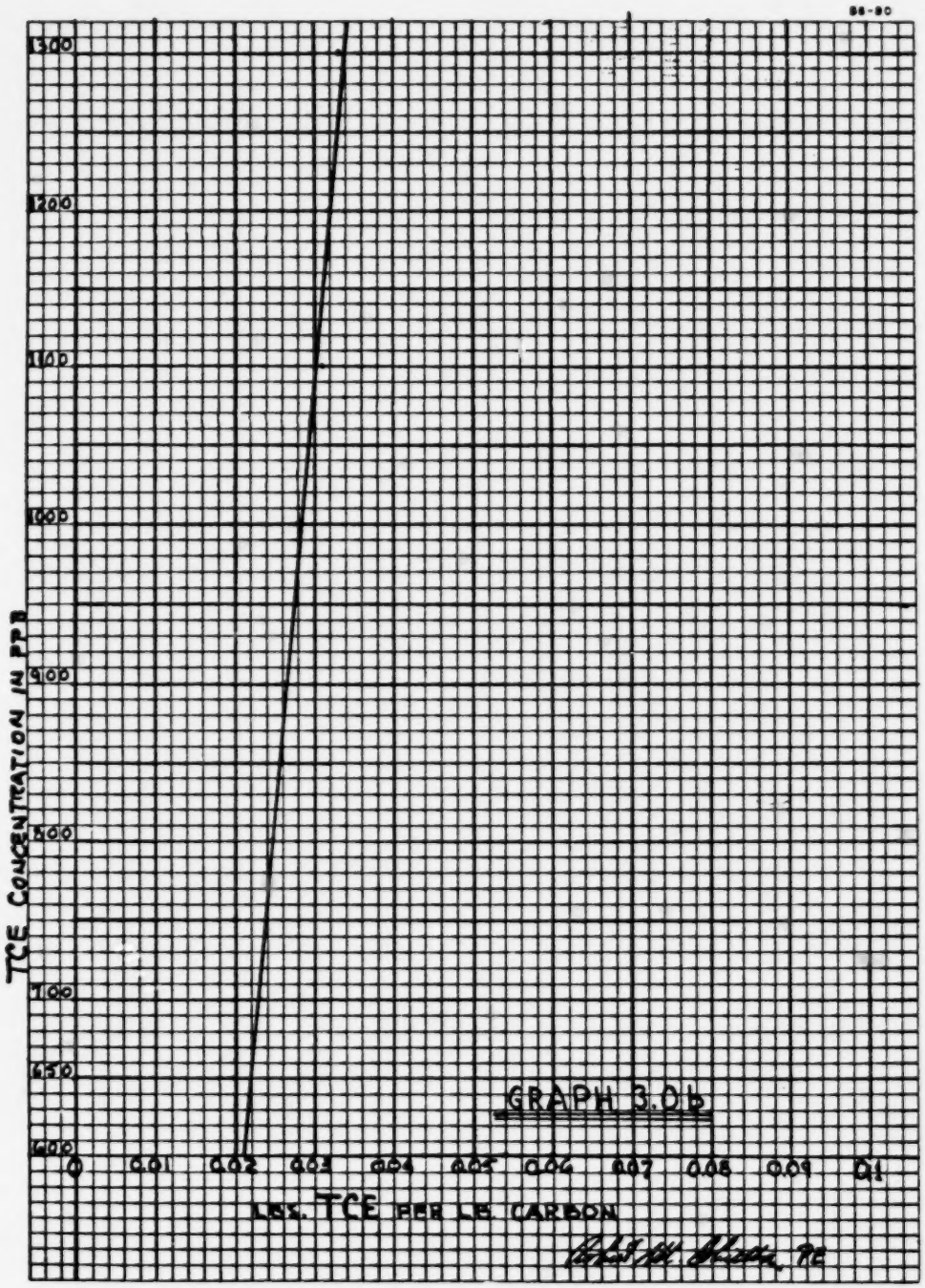
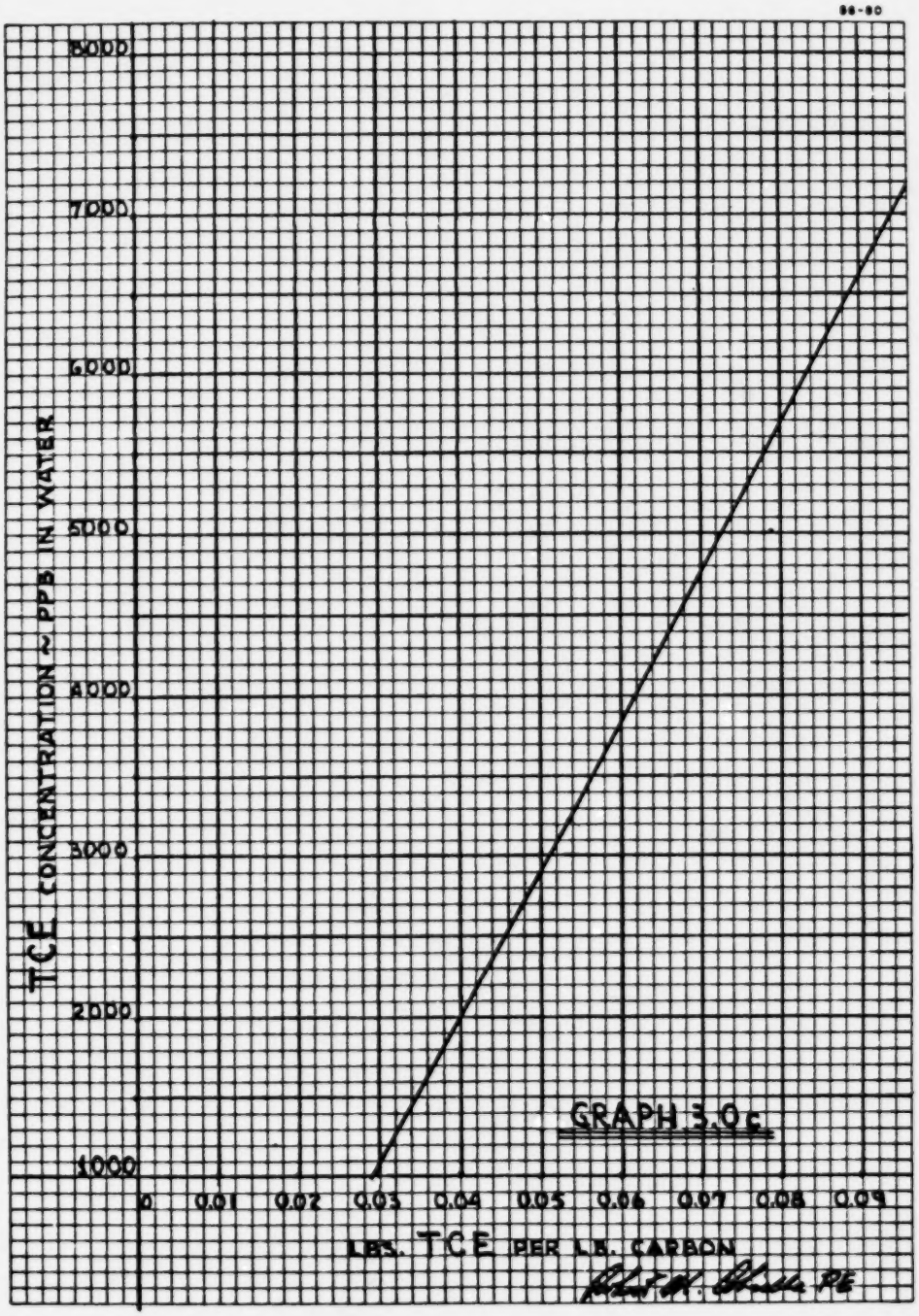
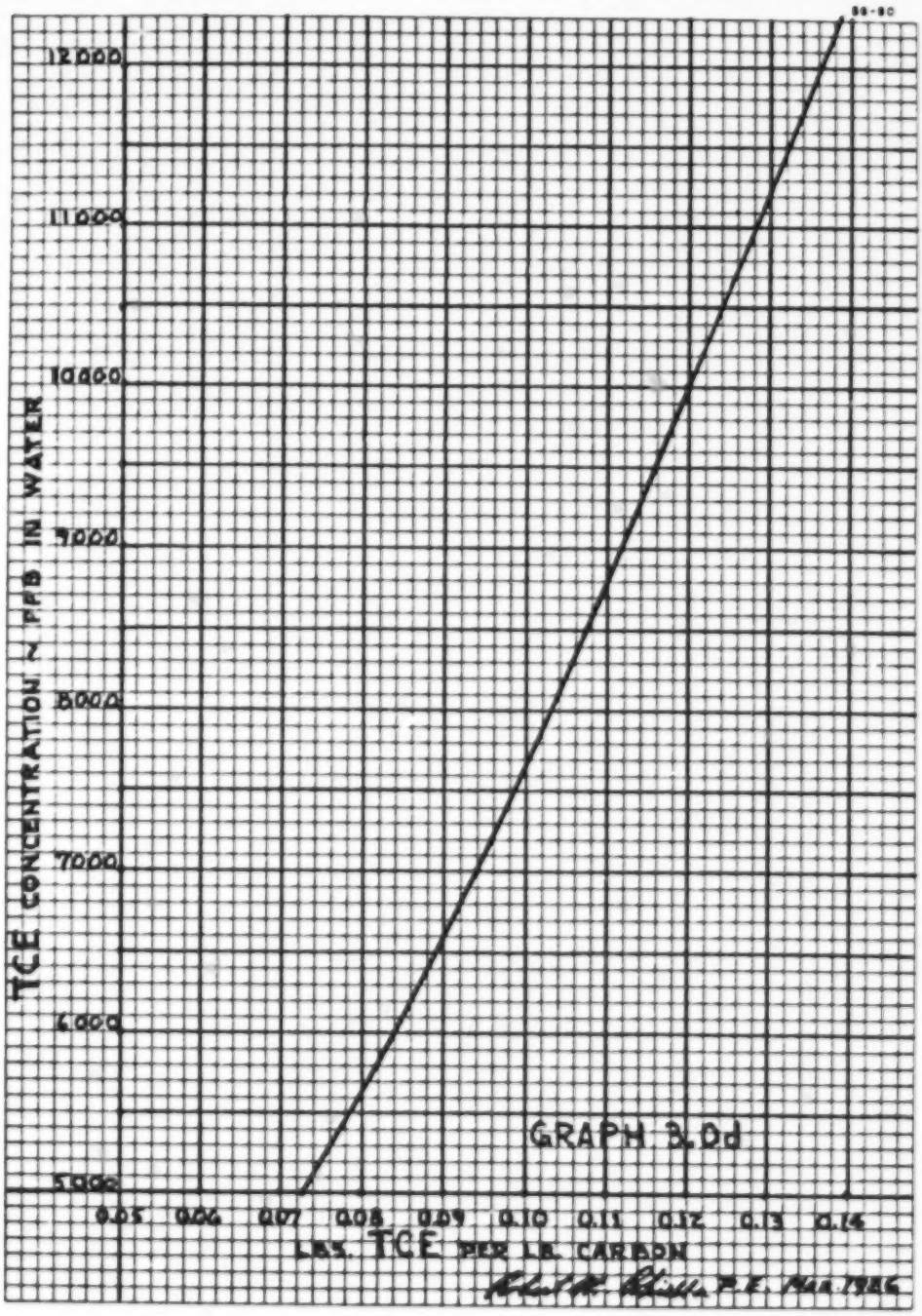

88-80
1300
1200
1100
1000
900
800
700
650
600
TCE CONCENTRATION IN PPB
0
0.01
0.02
0.03
0.04
0.05
0.06
0.07
0.08
0.09
0.1
LBS. TCE PER LB. CARBON

GRAPH 3.0 b


88-80
8000
7000
6000
5000
4000
3000
2000
1000
TCE CONCENTRATION ~ PPB IN WATER
0
0.01
0.02
0.03
0.04
0.05
0.06
0.07
0.08
0.09
LBS. TCE PER LB. CARBON
GRAPH 3.0c


12000
11000
10000
9000
8000
7000
6000
5000
TCE CONCENTRATION IN PPB IN WATER
0.05
0.06
0.07
0.08
0.09
0.10
0.11
0.12
0.13
0.14
LBS. TCE PER LB. CARBON
GRAPH 3.0d

3.21 SANDBURG OIL June 20, 1984

1641 East State Road
Olean, NY 14760
(716) 372-4444

10 Employee Shop

4/11/84 Sampling
@ 180 ppb. TCE

Average daily water usage:
10 Employees x 15 gpd/Employee = 150 gpd

Instantaneous water demand - 5 gpm

*from NYSDOH isotherm:

$$@\ 180\ ppb = \frac{0.0099\ lb\ TCE}{1\ lb\ C} = \frac{x}{25.3\ lb} \qquad x = 0.25\ lb\ TCE$$

$$\frac{180\ lb}{1 \times 10^{9}\ lb} \times \frac{150\ gpd}{7.4805\ g/ft^{3}} \times 62.4\ lb/ft^{3} = 2.25 \times 10^{-4}\ lb/day$$

$$\text{Longevity:} \quad \frac{0.25\ lb}{2.25 \times 10^{-4}\ lb/day} = 1110\ days$$

Note: Sandburg Oil Company has two wells. Only that one which is used for sanitary purposes will be treated.

2 RU30 units

10" dia x 54" h
.55 ft^2 surface area

1 cu. ft.
per each unit

Data per each unit: 5.5 gpm

*NYSDOH isotherm date from Dobbs and Cohen, EPA Study, April 1980.

3.22 MASTEL FORD

June 20, 1984

1674 East State Road
Olean, NY 14760
(716) 372-7272

Car Dealership
35 Employees

4/6/84 Sampling
@ 660 ppb TCE

Note: Filter to be installed on drinking fountain supply.

Average daily water usage:
@ 1 qt./person/day = 10 gal/day

Instantaneous water demands: Low (<3.5 gpm)

*From NYSDOH isotherm:

$$@\ 660\ \text{ppb} = \frac{0.023\ \text{lb TCE}}{1\ \text{lb C}} = \frac{x}{1/2(25.3)\ \text{lb}}\ x = .29\ \text{lb TCE}$$

$$\frac{660\ \text{lb}}{1 \times 10^9\ \text{lb C}} \times \frac{10\ \text{gpd}}{7.4805\ \text{gal/ft}^3} \times 62.4\ \text{lb/ft}^3 = 5.5 \times 10^{-5}\ \text{lb/day}$$

$$\text{Longevity:}\ \frac{0.29\ \text{lb}}{5.5 \times 10^{-5}\ \text{lb/day}} = 5290\ \text{days}$$

2 RU17 units
1/2 cu. ft.
per each unit

8" dia x 36" h
0.35 ft^2 surface area
Data per each unit
3.5 gpm

Note: Column selected is smallest available size suitable for this service and installation.

* NYSDOH isotherm from Dobbs and Cohen, EPA Study, April 1980

3.23 ZUCKERMAN, Gary

June 20, 1984

East State Road
Olean, NY 14760
(716) 372-4867

1 Family residence 400 gpd

5/15/84 Sampling
@ 180 ppb

Instantaneous water usage: 9 gpm total : (need .9 ft^2)

Average daily waer usage: 400 gpd

*From NYSDOH isotherm:

$$@\ 180\ ppb = \frac{0.0099\ lb\ TCE}{1\ lb\ C} = \frac{x}{3(25.3)\ lb} \quad x = 0.75\ lb\ TCE$$

$$\frac{180\ lb}{1 \times 10^9\ lb} \times \frac{400\ gpd}{7.4805\ g/ft^3} \times 62.4\ lb/ft^3 = 6.01 \times 10^{-4}\ lb/day$$

Longevity: $0.75\ lb / 6.01 \times 10^{-4}\ lb/day = 1249$ days

Note: Filters for residences were designed considering the highest concentration found at an area residence during the sampling.

2 RU64 units	13" dia x 55" h
	.92 ft^2 surface area
3 cu. ft.	Data per each unit
per each unit	9.2 gpm

*NYSDOH isotherm data from Dobbs and Cohen, EPA Study, April 1980.

3.24 SCICCHITANO, Constantine

June 20, 1984

East State Road
Olean, NY 14760
(716) 372-6368

1 3-bedroom apt. (400 gpd)
2 1-bedroom apt. (150 gpd ea.)

4/3/84 Sampling
@ 240 ppb

Instantaneous water usage:

5 gpm/unit: 1 + 2(150/400) = 1.75 units

5 gpm (1.75 units) = 8.75 gpm Total (need .875 ft^2)

Average daily water usage: 700 gpd

*From NYSDOH isotherm:

$$@\ 240\ ppb = \frac{0.015\ lb\ TCE}{1\ lb\ C} = \frac{x}{3(25.3)\ lb}\quad x = 0.87\ lb\ TCE$$

$$\frac{240\ lb}{1 \times 10^9\ lb} \times \frac{700\ gpd}{7.4805\ g/ft^3} \times 62.4\ lb/ft^3 = 1.4 \times 10^{-3}\ lb/day$$

Longevity: 0.87 lb/1.4 x 10^{-3} lb/day = 621 days

2 RU64 units
3 cu. ft. per each unit

13" dia x 55" h
.92 ft^2 surface area
Data per each unit
9.2 gpm

*NYSDOH isotherm data from Dobbs and Cohen, EPA Study, April 1980

3.25 CENTURY 21 - DOUGLAS AGENCY June 20, 1984

East State Road
Olean, NY 14760
(716) 372-3400

4/6/84 Sampling
@ 1100 ppb TCE

1 real estate agency
1 apartment Total: 400 gpd

Instantaneous water usage: 9 gpm total (need .9 ft^2)

Average daily water usage 400 gpd

*From NYSDOH isotherm

$$@\ 1100\ ppb = \frac{.030\ lb\ TCE}{1\ lb\ C} = \frac{x}{3(25.3)\ lb}\ x = 2.3\ lb\ TCE$$

$$\frac{1100\ lb}{1 \times 10^9\ lb} \times \frac{400\ gpd}{7.4805\ g/ft^3} \times 62.4\ lb/ft^3 = 3.67 \times 10^{-3}\ lb/day$$

$$\text{Longevity: } \frac{2.3\ lb}{3.67 \times 10^{-3}\ lb/day} = 627\ days$$

2 RU64 units 13" dia x 55' h
.92 ft^2 surface area

3 cu. ft. per ea. unit Data per ea. unit
9.2 gpm

*NYSDOH isotherm data from Dobbs and Cohen, EPA Study, April 1980

3.26 FARBER, John

June 20, 1984

East River Road
Olean, NY 14760
(716) 372-6409

1 Family residence 400 gpd

4/20/84 Sampling
@ 140 ppb TCE

Instantaneous water usage: 9 gpm total (need .9 ft^2)

Average daily water usage: 400 gpd

*From NYSDOH isotherm:

$$@\ 140\ ppb = \frac{0.0084\ lb\ TCE}{1\ lb\ C} = \frac{x}{3(25.3)\ lb} \quad x = 0.64\ lb\ TCE$$

$$\frac{140\ lb}{1 \times 10^9\ lb} \times \frac{400\ gpd}{7.4805\ g/ft^3} \times 62.4\ lb/ft^3 = 4.67 \times 10^{-4}\ lb/day$$

Longevity: $0.64\ lb / 4.67 \times 10^{-4}\ lb/day = 1370$ days

2 RU64 units
3 cu. ft. per ea. unit

13" dia x 55" h
.92 ft^2 surface area
Data per ea. unit
9.2 gpm

Notes:
1. Filters for the residences were designed considering the highest concentration found at an area residence during the sampling.

2. Subsequent inspection determined that above figures are not as conservative as they look because the Farbers installed a line from the interstage to their horse barn. Flow for the primary GAC column may therefore be higher than assumed above.

*NYSDOH isotherm data from Dobbs and Cohen, EPA Study, April 1980

3.27 HURLBERT, Ronald

June 20, 1984

1026 Billington Avenue
Olean, NY 14760
(716) 372-9589

1 Family residence (400 gpd)

5/21/84 Sampling
@ 240 ppb TCE

Instantaneous water usage: 9 gpm total (need .9 ft^2)

Average daily water usage: 400 gpd

*From NYSDOH isotherm:

$$@\ 240\ ppb = \frac{0.0115\ lb\ TCE}{1\ lb\ C} = \frac{x}{3(25.3)\ lb} \quad x = 0.87\ lb\ TCE$$

$$\frac{240\ lb}{1 \times 10^9\ lb} \times \frac{400\ gpd}{7.4805\ g/ft^3} \times 62.4\ lb/ft^3 = 8.0 \times 10^{-4}\ lb/day$$

Longevity: $0.87\ lb / 8.0 \times 10^{-4}\ lb/day = 1086$ days

2 RU64 units
3 cu. ft. per ea. unit

13" dia x 55" h
.92 ft^2 surface area
Data per ea. unit
9.2 gpm

Note: Filters for residences were designed considering the highest concentration found at an area residence during the sampling.

*NYSDOH isotherm data from Dobbs and Cohen, EPA Study, April 1980

3.28 DON RA TAVERN

June 20, 1984

E. State Road
Olean, NY 14760

Tavern with little food service
31 seats

4/5/84 Sampling
@ 67 ppb TCE

Average daily water usage:
20 gpd/seat x 31 seats = 620 gpd

Instantaneous water demand: <9 gpm
(Need <.9 ft^2)

*From NYSDOH isotherm:

$$@\ 67\ ppb = \frac{.0052\ lb\ TCE}{1\ lb\ C} = \frac{x}{3(25.3)\ lb} = x = 0.39\ lb\ TCE$$

$$\frac{67\ lb}{1 \times 10^9\ lb} \times \frac{620\ gpd}{7.4805\ g/ft^3} \times 62.4\ lb/ft^3 = 3.47 \times 10^{-4}\ lb/day$$

$$\text{Longevity:} \quad \frac{0.39\ lb}{3.47 \times 10^{-4}\ lb/day} = 1125\ days$$

2 RU64 units — 13" dia x 55" h
.92 ft^2 surface area
3 cu. ft. per ea. unit — Data per ea. unit
9.2 gpm

Note: Filter designed considering the higher concentrations in the area and the movement of the TCE already observed.

*NYSDOH isotherm data from Dobbs and Cohen, EPA Study, April 1980

3.29 BURTON'S TRAILER PARK June 20, 1984

c/o Harry Burton
E. State Road
Olean, NY 14760
(716) 372-2812

1 house (400 gpd)
5 mobile homes (250 gpd ea.)

4/3/84 Sampling
@ 440 ppb TCE

Instantaneous water usage:

$$5 \text{ gpm/unit} : 1 + \frac{250}{400}(5) = 4 \text{ units}$$

5 gpm (4 units) = 20 gpm total (need 2 ft^2)

Average daily water usage:

400 + 5(250) = 1650 gpd

*From NYSDOH isotherm:

$$@ 440 \text{ ppb} = \frac{.017 \text{ lb TCE}}{1 \text{ lb C}} = \frac{x}{8(25.3) \text{ lb C}} \quad x = 3.4 \text{ lb TCE}$$

$$\frac{440 \text{ lb}}{1 \times 10^9 \text{ lb}} \times \frac{1650 \text{ gpd}}{7.4805 \text{ g/ft}^3} \times 62.4 \text{ lb/ft}^3 = 6.06 \times 10^{-3} \text{ lb/day}$$

$$\text{Longevity: } \frac{3.4 \text{ lb}}{6.06 \times 10^{-3} \text{ lb/day}} = 561 \text{ days}$$

2 M160 units
8 cu. ft. per ea. unit

21" dia x 63" h
2.4 ft^2 surface area
Data per ea. unit
24 gpm

*NYSDOH isotherm data from Dobbs and Cohen, EPA Study, April 1980

3.30 MISIANO AND COSS TRAILER PARK - East State Road

c/o Robert Fairbanks
9 Sunset Ridge Drive
Portville, NY 14770
(716) 933-7540

June 20, 1984

8 mobile homes (250 gpd ea.)
6 one-bedroom apt. (150 gpd ea.)

5/15/84 Sampling
@ 1200 ppb TCE

Instantaneous water usage:

5 gpm/unit: $8\frac{(250)}{(400)} + 6\frac{(150)}{(400)} = 7.25$ units

5 gpm (7.25 units) = 36.25 gpm total (need 3.6 ft^2)

Average daily water usage:

8 (250) + 6 (150) = 2900 gpd

*From NYSDOH isotherm:

$$@\ 1200\ ppb = \frac{0.033\ lb\ TCE}{1\ lb\ C} = \frac{x}{16(25.3)\ lb\ C}\quad x = 13.4\ lb\ TCE$$

$$\frac{1200\ lb}{1 \times 10^9\ lb} \times \frac{2900\ gpd}{7.4805\ g/ft^3} \times 62.4\ lb/ft^3 = 2.9 \times 10^{-2}\ lb/day$$

Longevity: 13.4 lb/2.9×10^{-2} lb/day = 462 days

4 M160 units — 21" dia x 63" h
2.4 ft^2 surface area
8 cu. ft. per ea. unit — Data per ea. unit
24 gpm

Note: The first pair of filters (connected in series) will be in parallel with the other pair.

*NYSDOH isotherm from Dobbs and Cohen, EPA Study, April 1980